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(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

JANUARY, 1907.

2-8 2 TYPE ELECTRIC LOCOMOTIVE.

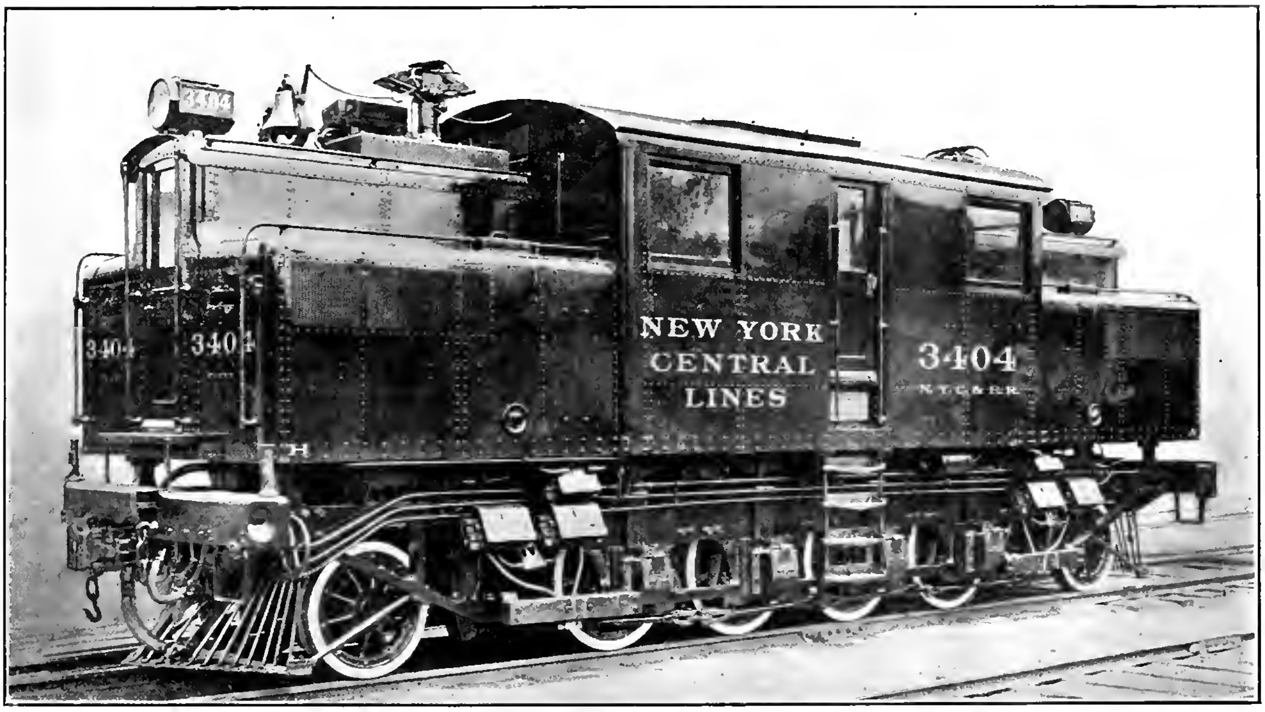
NEW YORK CENTRAL LINES.

During the past month the New York Central & Hudson River Railroad Company has started partial electric train service on what is known as the initial electric zone extending from the Grand Central Station, New York, to High Bridge, a distance of 7.1 miles on the Hudson Division and to Wakefield, a distance of 12.5 miles on the Harlem Division. This service employs electric motor cars and trailers for the suburban trains and powerful electric locomotives for the express trains. Direct current of 650 volts, supplied ordinarily through an under contact third rail and through overhead contact at cross overs, road crossings, etc., is used.

The electric locomotives, 35 of which have been received, were built by the General Electric and American Locomotive Companies, and are considerably more powerful than any steam passenger locomotives now in high speed service. They weigh 200,500 lbs. total, of which 142,000 lbs. is on the four pairs of driving wheels. The tractive effort is 34,000 lbs., giving a ratio of 1 to 4.18 with the weight on drivers and 1 to 5.9 with the total weight. The normal horse power which can be developed is 2,200 or 550 h.p. per motor. This, however, can be increased to 3,000 h.p. at starting or for short intervals in running. The motors are of the gearless type, the armatures being mounted directly upon the axles of the driving wheels. The specifications call for a maximum speed of these locomotives of from 60 to 65 miles per hour, which with the 44 in. driving wheels, will give about 460 r.p.m. of the motors. This speed is to be made with a 500 ton train. For trains of greater weight two of the locomotives can be coupled together and operated on the multiple unit system.

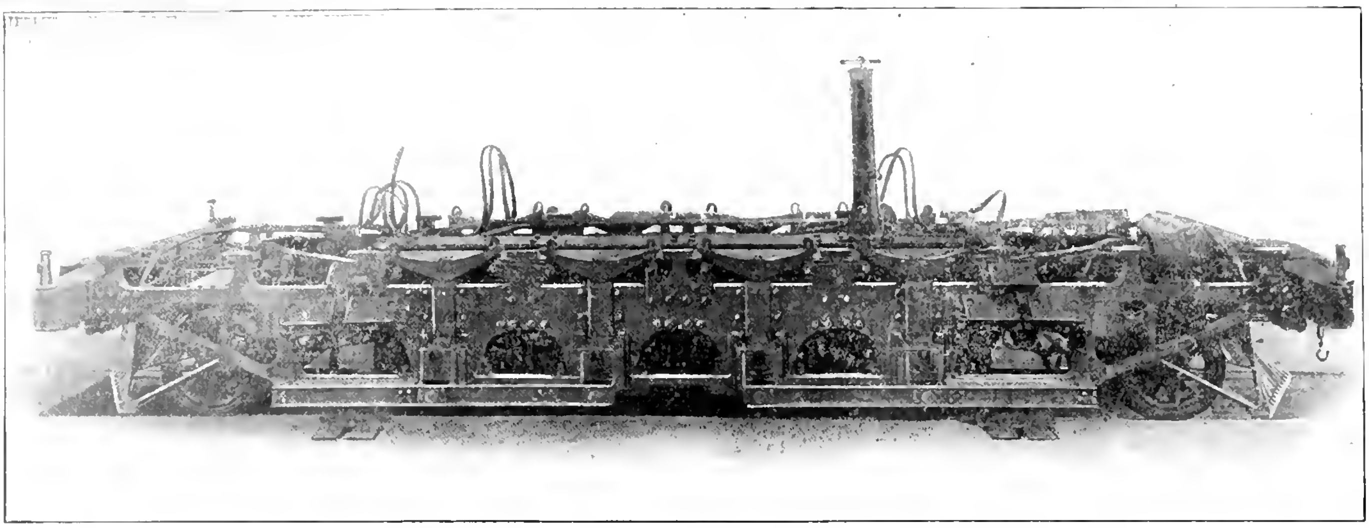
The first experimental locomotive of this type, which was No. 6,000, was finished about two years ago, and was put into service on a short experimental section of track near Schenectady, where very complete service tests were made of all its features. This locomotive was run for a total distance of 50,000 miles under all weather conditions, and all the weak points were discovered and remedied before the building of the first order of 35.

During this experimental service some very satisfactory figures were obtained in respect to the acceleration and high speed qualities of the locomotive. One of the most interesting of this series was an actual competition, or race, between electric locomotive No. 6,000 and a large Pacific type passenger locomotive, which had approximately the same weight on drivers, both locomotives hauling the same weight train. A series of runs with varying conditions were made, and an account giving the conditions and results was published in this journal June, 1905, page 225. It was found at that time that the electric locomotive was capable of an acceleration of .394 miles per hour per second to about 50 m.p.h., while the steam locomotive was capable of but .246 m.p.h. per second. Also that the time required to reach a speed of 50 miles per hour with a six car train weighing 407.5 tons for the electric and 427 for the steam, was about 127 seconds, for the electric and 203 seconds for the steam. These figures clearly show wherein the biggest advantage from an operating standpoint of the electric service lies. Also during this series of tests the electric locomotive was capable of attaining over 85 m.p.h. when running light, although in this connection it must be understood that these machines were not designed for specially high speeds. Accurate figures were also obtained on the cost of operating and maintaining the electric locomotives, which in spite of some unusual accidents, among which was the burning of the shed in which the locomotive was housed, were, as compared with similar figures for the steam locomotive, very low.

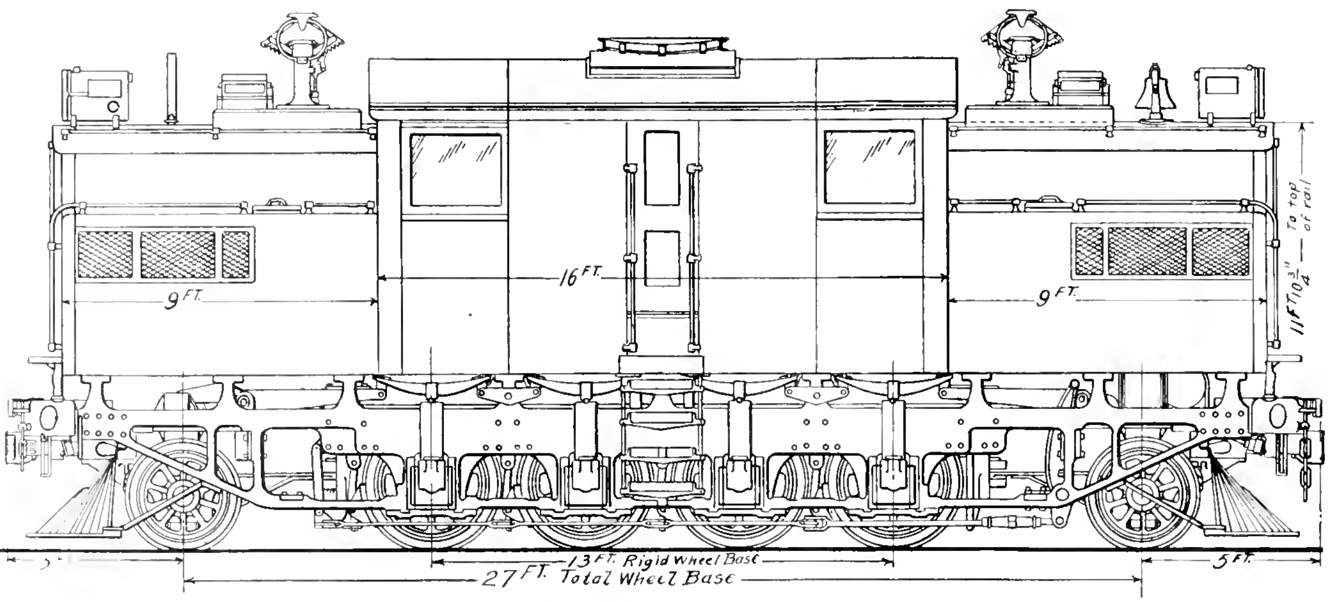


ELECTRIC PASSENGER LOCOMOTIVE, NEW YORK CENTRAL LINES.

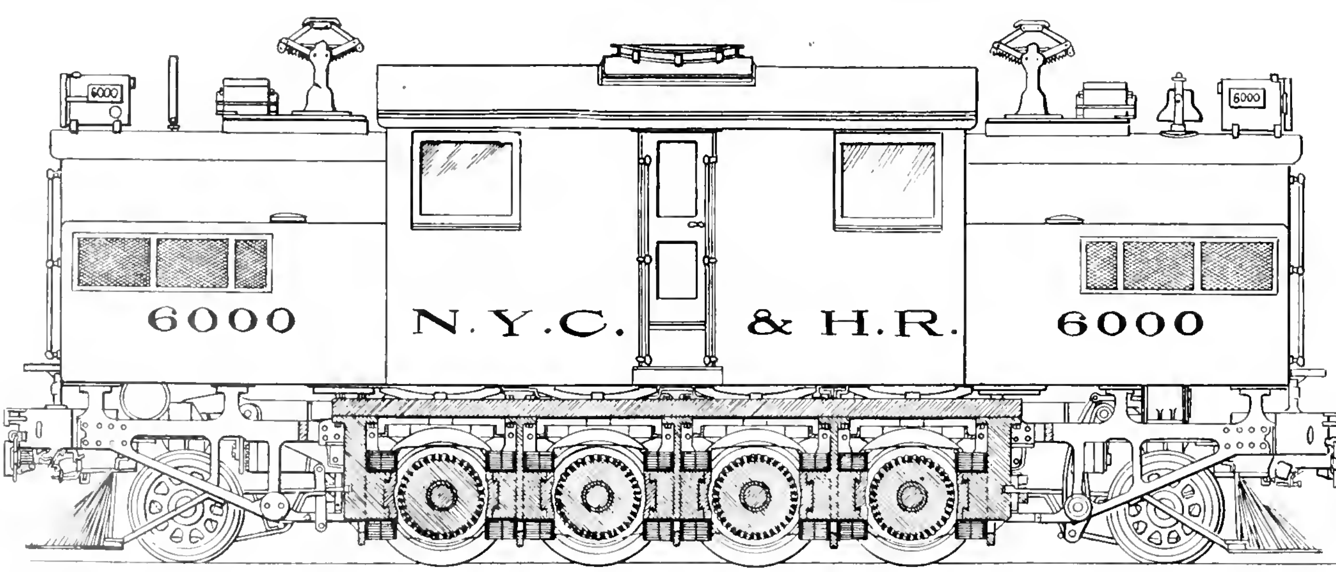
The illustrations give a clear idea of the general structure of the locomotive, and it will be noted that many features of steam locomotive design have been incorporated in this machine, notably the fact that the power is transmitted from the drivers through the two main frames to the end casting, in which is located the draft gear. The cab is simply superimposed on these frames and is built of light structural steel shapes and plates. The side frames are outside of the driving wheels and are made of cast steel. They extend continuously from end sill to end sill and have the driving boxes fitted into pedestals in the ordinary manner, there being a difference from steam locomotive practice



UNDERFRAME AND RUNNING GEAR OF ELECTRIC LOCOMOTIVE, NO. 6000.



SIDE ELEVATION OF NEW YORK CENTRAL ELECTRIC LOCOMOTIVE.

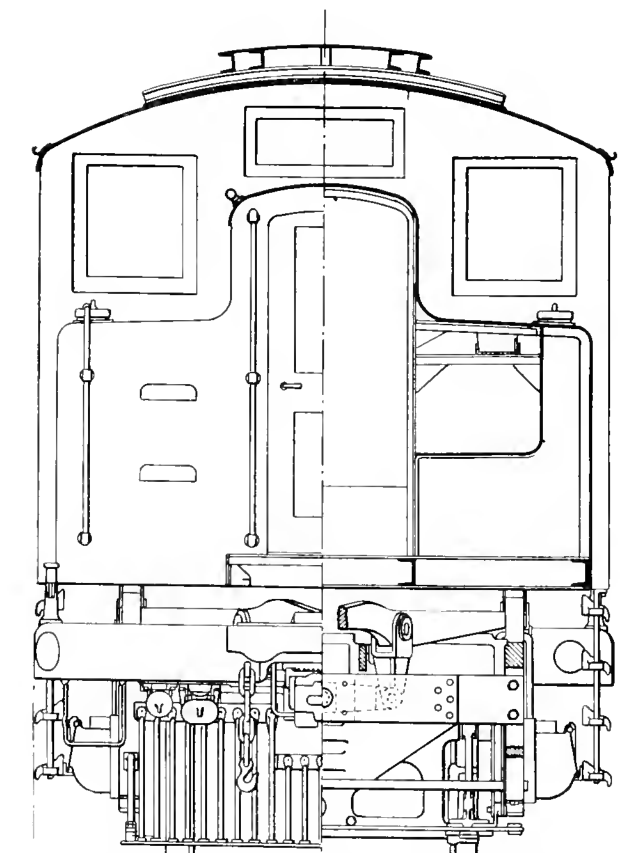


SECTION THROUGH MOTORS, NEW YORK CENTRAL ELECTRIC LOCOMOTIVE.

in that there are no wedges, both pedestal jaws being fitted with cast iron shoes. The end frames are heavy steel castings securely bolted to the side frames and are fitted with pockets for the draft gear and platform springs. In addition to these there are five transverse steel castings, or cross ties, fitted and bolted to the side frames, there being one between each pair of drivers and one at either end just outside of the driving wheels. These transverse castings support the field magnets of the

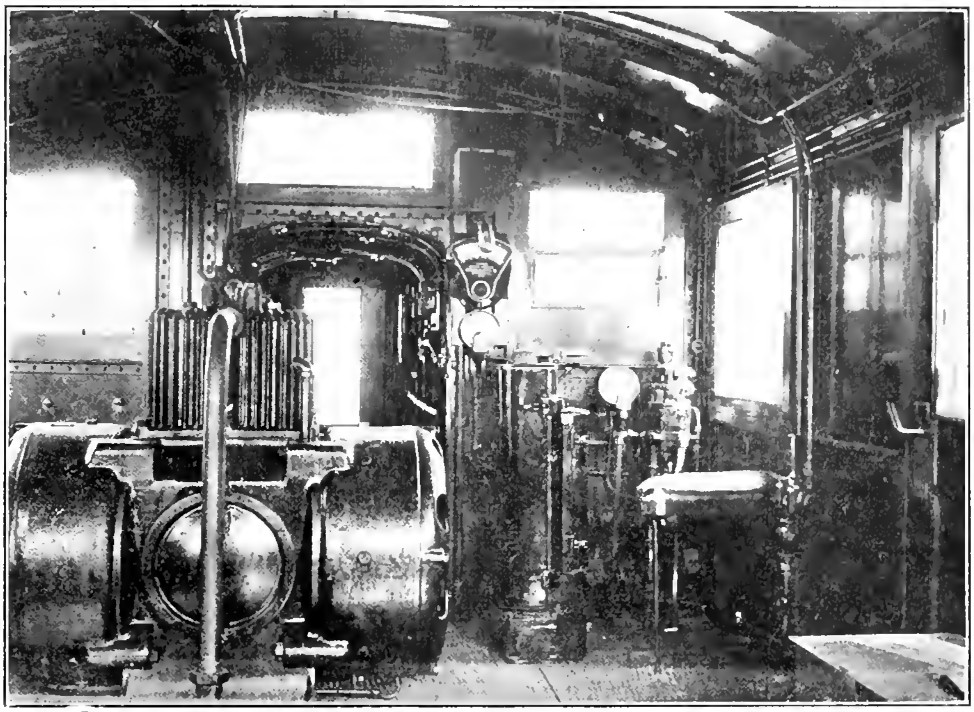
motors, the three centre ones supporting a coil on either side and the end ones supporting a coil on the inner side only and having lugs on the opposite side for attaching the pony truck radius bar. The pony trucks, of which there is one at either end of the locomotive, are of the usual locomotive design.

The springs and equalizers are placed above the frame, there being a sem-elliptic spring, resting by means of the saddle on top of each driving box. The first and second pair of drivers are equalized together with the pony truck on that end, there being a difference, however, in the two ends of the locomotive, which is partially shown in one of the illustrations, in that the two equalizers of the pony truck at one end are themselves fulcrumed on the ends of a short transverse equalizer, thus forming a system which gives a three point suspension to the locomotive. Above the cast steel cross ties there are two longitudinal steel pieces of about 36 sq. ins. in section which are so located with reference to the centre line of the locomotive as to equalize the uneven balance caused by the necessary off-setting of the armature on the axle and consequently of the field coils. These longitudinal pieces are also of value in forming part of the magnetic circuit of the motors.



END ELEVATION AND SECTION, ELECTRIC LOCOMOTIVE.

The central portion of the superstructure or the cab proper, consists of a large open room in which are located the motorman's controlling apparatus, which is in duplicate, one set at each end; the electric air pump, and also a space in which eventually will be installed a boiler for steam train heating. One of the illustrations gives a view of the interior of the cab, showing the location and arrangement of the apparatus.

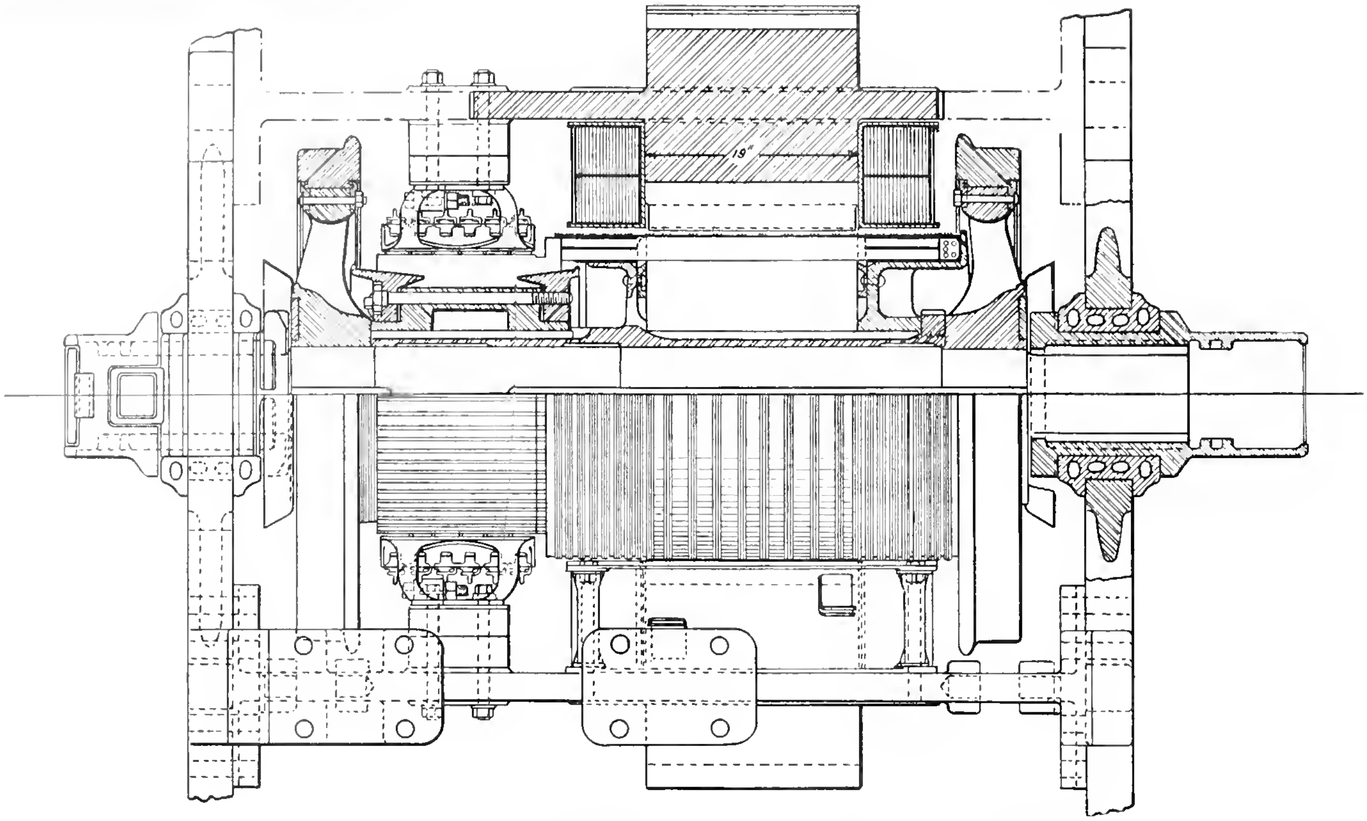


VIEW OF INTERIOR OF CAB, ELECTRIC LOCOMOTIVE.

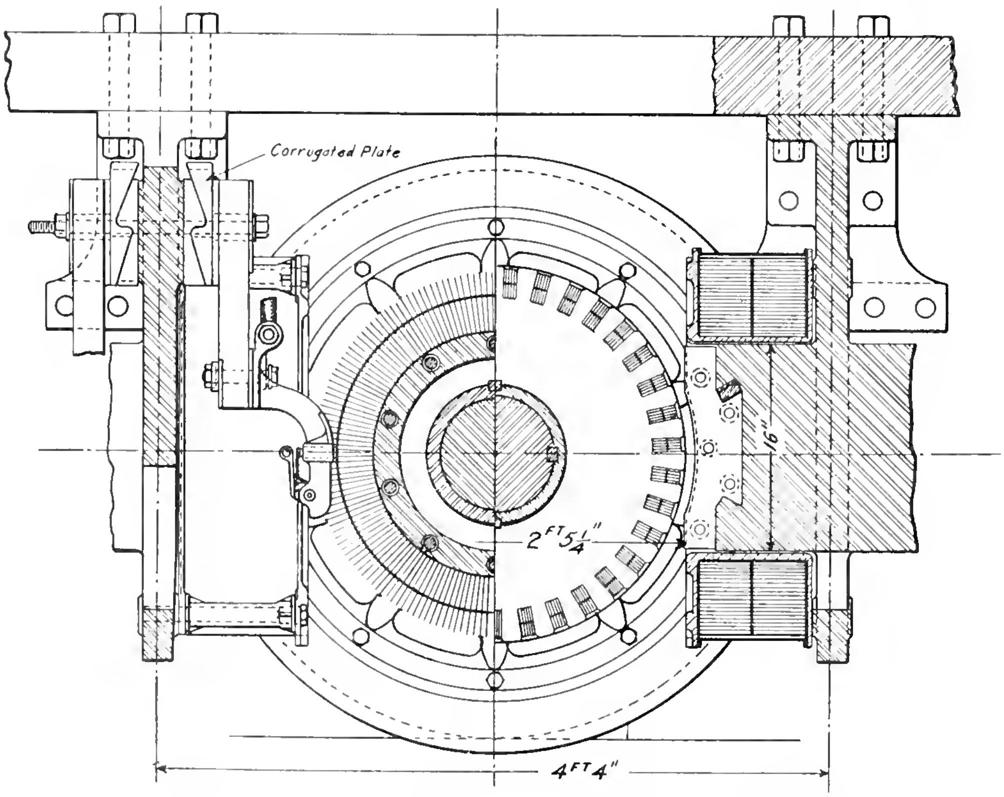
It is about 16 ft. long, by 9 ft. wide and from it extends an alleyway or corridor leading to a door at either end. On either side of this corridor are placed the rheostats, contactors and switches of all kinds. The section containing this apparatus, while of the full width of the locomotive, is made low enough to give an unobstructed forward and rear view from the cab windows. Careful attention to details is noticed in the construction of the cab and by means of butt joints in the plates and careful finish, the exterior presents an excellent appearance. In the interior special care has been given to prevent any possibility of accident and all conductors are not only heavily insulated, but also carried in pipes whereever possible.

The convenient arrangement of the motorman's control apparatus is shown in the interior view of the cab. When seated on the ordinary drop seat of locomotive type the motorman has at his right a large sliding window and ahead a double sash window, the lower sash of which can be swung out and adjusted at any angle. At his left is the main controller with a long lever, resembling a throttle lever, in a position easily reached when leaning out of the side window. Immediately in front, below the front window, is located the engineer's brake valve, alongside of which is the air guage. Within easy view are also located a volt and ammeter. To his right just below the side window is the valve controlling the raising and lowering of the trolleys, which are operated by air pressure and just behind him is a valve for the air sanders. A bell rope and whistle cord are within reach and two electric heaters are located on the front wall near the floor. All guages are illuminated by shaded lamps. The switches for electric headlights, cab light, etc., are in the corridors.

The current is collected from the third rail by four shoes of the design shown in one of the illustrations. These are carried from wooden blocks fastened to the locomotive frames, and are spring supported and arranged for a vertical play of about 2 ins. They are adapted for making contact with either over or under running third rails. There are also two pantagraph type sliding trolleys, mounted on top of the locomotive for collecting current from overhead rails when



PLAN AND SECTION OF GEARLESS MOTORS, NEW YORK CENTRAL ELECTRIC LOCOMOTIVE.



END ELEVATION AND SECTION OF GEARLESS MOTORS, ELECTRIC LOCOMOTIVE.

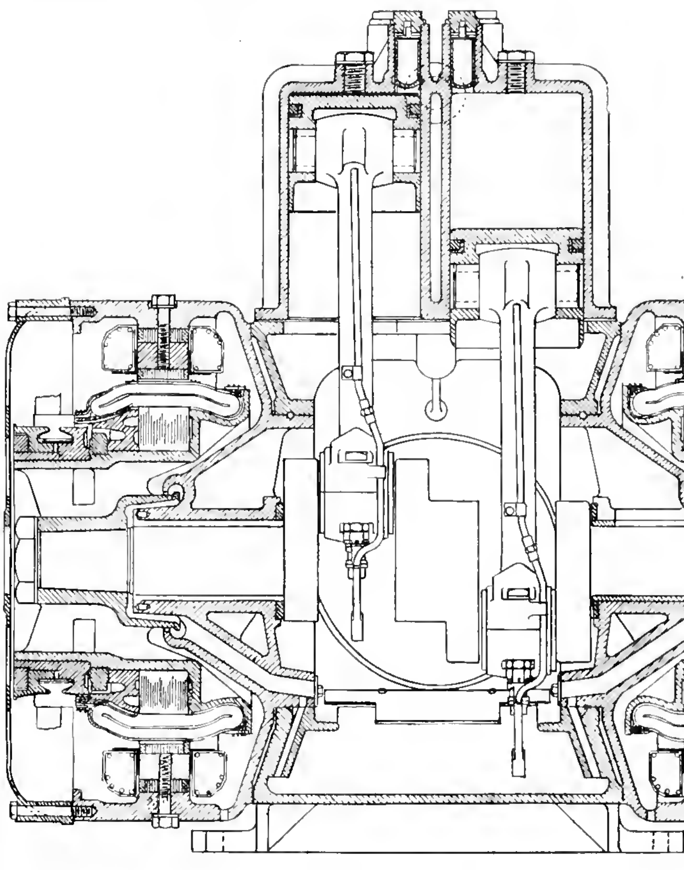
necessary. These are raised and lowered by air pressure. Both the shoes and trolleys have a fuse placed in boxes lined with fireproof material and located on the outside of the locomotive, close to the point of contact.

The motors are two pole direct current series wound and are rated at 550 h.p. each. They are built to withstand an over-load of 50 per cent. for one hour, with a rise of temperature not to exceed 75 degs. The pole faces are made practically flat so that the driving wheels with the armature can be removed by means of a drop pit without disturbing the field coils. The core of the field coil, as above mentioned, is integral with the steel cross ties, the faces being made up of laminated soft iron sections dovetailed into the cast steel cores and held in position by the field coils.

The brush holders are mounted on insulated supports secured to a lug cast on the frame cross ties, and are arranged to allow a considerable degree of vertical adjustment. This construction, as well as other features of the motor, are clearly shown in the illustrations of the cross sections through the motors. It will be seen that since the armature is rigid on the drivers and the field coils and brushes are carried on the frame that there will be at all times considerable vertical movement between these parts and hence all parts of the motors are arranged to suit. The air gap between the armature and pole face is nominally ¼ of an inch.

The Sprague-General Electric multiple unit system of control is used on these locomotives, and the motorman's controller located in the cab is the master controller for operating the contacts located in the end portions of the superstructure. Notches on the master controller, however, correspond directly to the different contacts on the main controller, and are divided into three general sections. The first section connects all four motors in series together with a certain amount of resistence and for each notch of the controller in the first group, parts of this resistance are cut out until the four motors are connected in series directly across the terminals. The next group at the first notch connects the motors in groups of two motors, which are in series, the two groups being in multiple with resistance in

the circuit. As the handle is still further pulled back, each notch cuts out more resistance until it has all been cut out. The controller then passes to the third group, where all motors are connected in multiple, there being at the first notch of this group resistance in the circuit, which resistance is again gradually cut out until finally at the last notch the motors are given the full amount of current when connected in multiple. The resistance consists of flat grids of cast iron mounted in cast iron frames from which they are insulated. The connection to the controller contacts is made by heavy copper bars. Cast iron is used for resistance because it is cheaper, has a high specific resistance and will stand a large amount of heat before any danger of short circuiting. In order to prevent burning out the motors by too rapid reduction of resistance in the circuit before they have come to speed, there is an electrical arrangement in the controller, which prevents it being moved to another notch before the motors have reached the proper speed. It is also



SECTION OF ELECTRIC AIR PUMP.

impossible to move the controller handle unless the reversing lever is fully thrown either forward or backward, this prevents burning out, caused by the controller handle being in a mid position before the current is thrown on by the reversing lever.

For the air brake and other pneumatic devices there is located in the cab, a double cylinder air compressor driven by two general electric 600 volt series motors. The appearance of this compressor is shown in one of the illustrations, and its construction is made clear by the cross section. It has a capacity of 75 cu. ft. of free air per minute, and is controlled by a governor, which automatically cuts the motors in and out of the circuit when the air pressure falls below 125 lbs. or exceeds 135 lbs.

Electric headlights are mounted on either end of the locomotive and behind them on one end is a regular locomotive bell, operated by either a cord or by a pneumatic bell ringer, and on the opposite end is an air whistle. The end upon which the whistle is located, and toward which the brake rod pushes is called the "A" or front end of the locomotive. No attention, however, is given to this in the direction of operation.

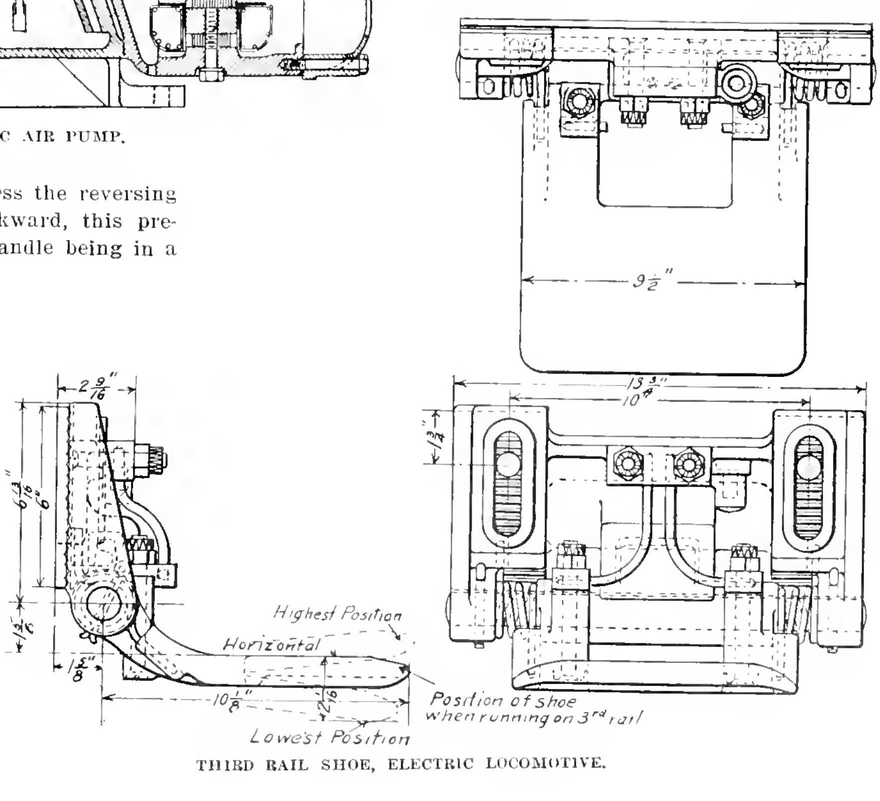
The table of general dimensions and weights follows:

No. of driving wheels	8
Total weight	200,500 lbs.
Weight on drivers	142,000 lbs.
Total wheel base	27 ft.
Driving wheel base	13 ft.
Diameter of drivers	44 in.
Diameter of truck wheels	36 in.
Diameter of driving axles	8.5 in.
Total length	37 ft.
Extreme width	10 ft.
Height to top of cab	14 ft. 4 in.
Normal rated power	2,200 h.p.
Maximum power	3,000 h.p.
Tractive effort	34,000 lbs.
Voltage of supply current	650 v.
Normal full load current	3,050 a.
Maximum full load current	4,300 a.
Type of motors	G E-34-A.

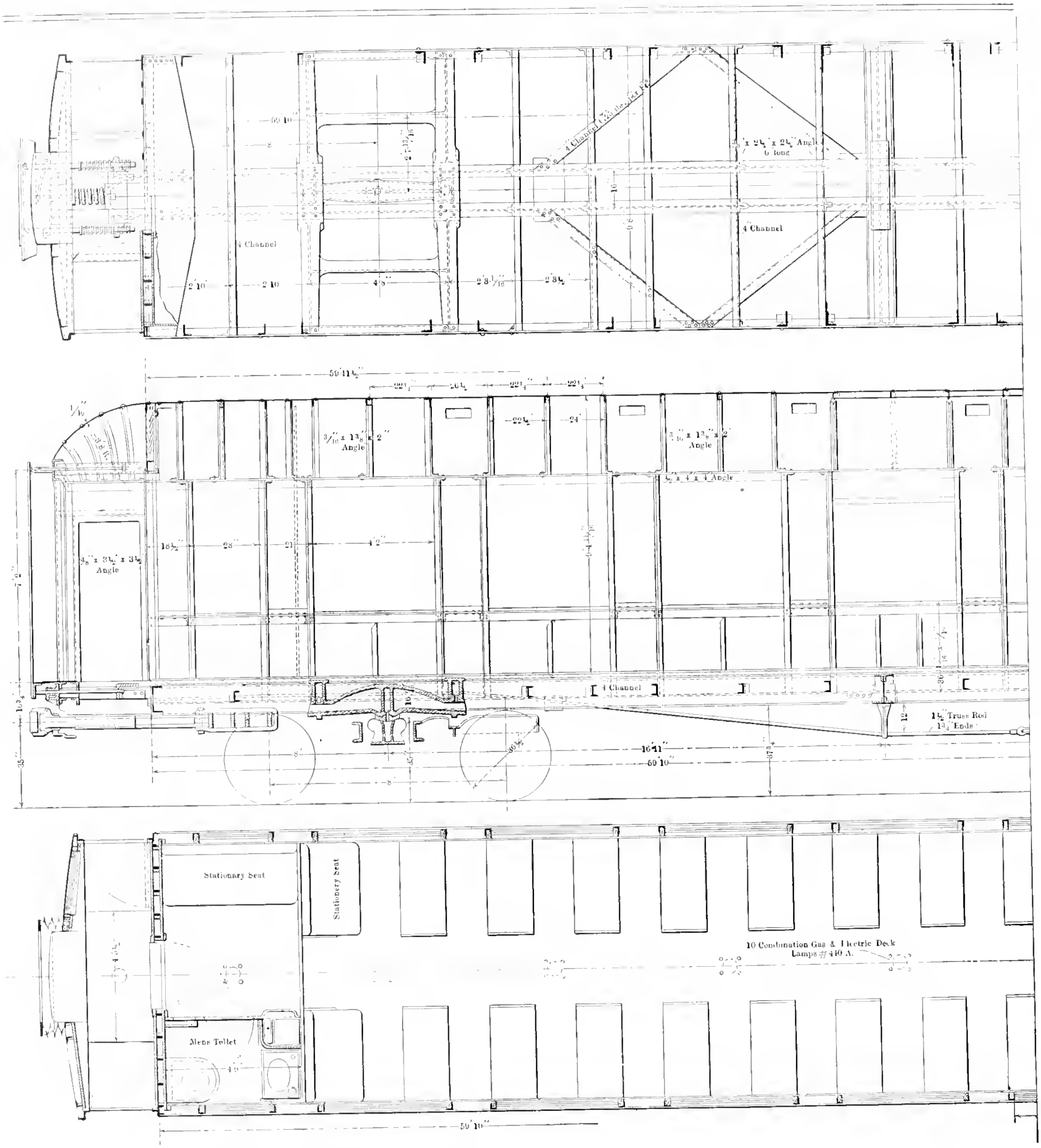
IGNORANCE.—Seven times out of ten, ignorance will abuse vested authority. The technical graduate as a beginner, if given authority, will display many forms of ignorance. "Get next."—*D. T. Taylor, St. Louis Railway Club.*

LESS RED TAPE.—First consider directness, which is the staff of business. This means that concentrated responsibility must carry with it concentrated authority. A man cannot produce results without power to remedy existing conditions. The path of the statement of net results should be the direct return path of the appropriation. But should this path in most cases lead clear to the vice-president's desk, or even the general manager's? It ought to be possible for an official to show a correctly figured plan for effecting economies to his superior and get the authority for expenditure therefor.—*Paul R. Brooks, before the New York Railroad Club.*

The officer who can smile as he comes in contact with those under him is best fitted to make those who neglect their duty tremble, since when he does look serious there is no question as to the seriousness of the offense.



THIRD RAIL SHOE, ELECTRIC LOCOMOTIVE.



STEEL PASSENGER CAR—HARRIMAN LINES

STEEL PASSENGER CAR.

HARRIMAN LINES.

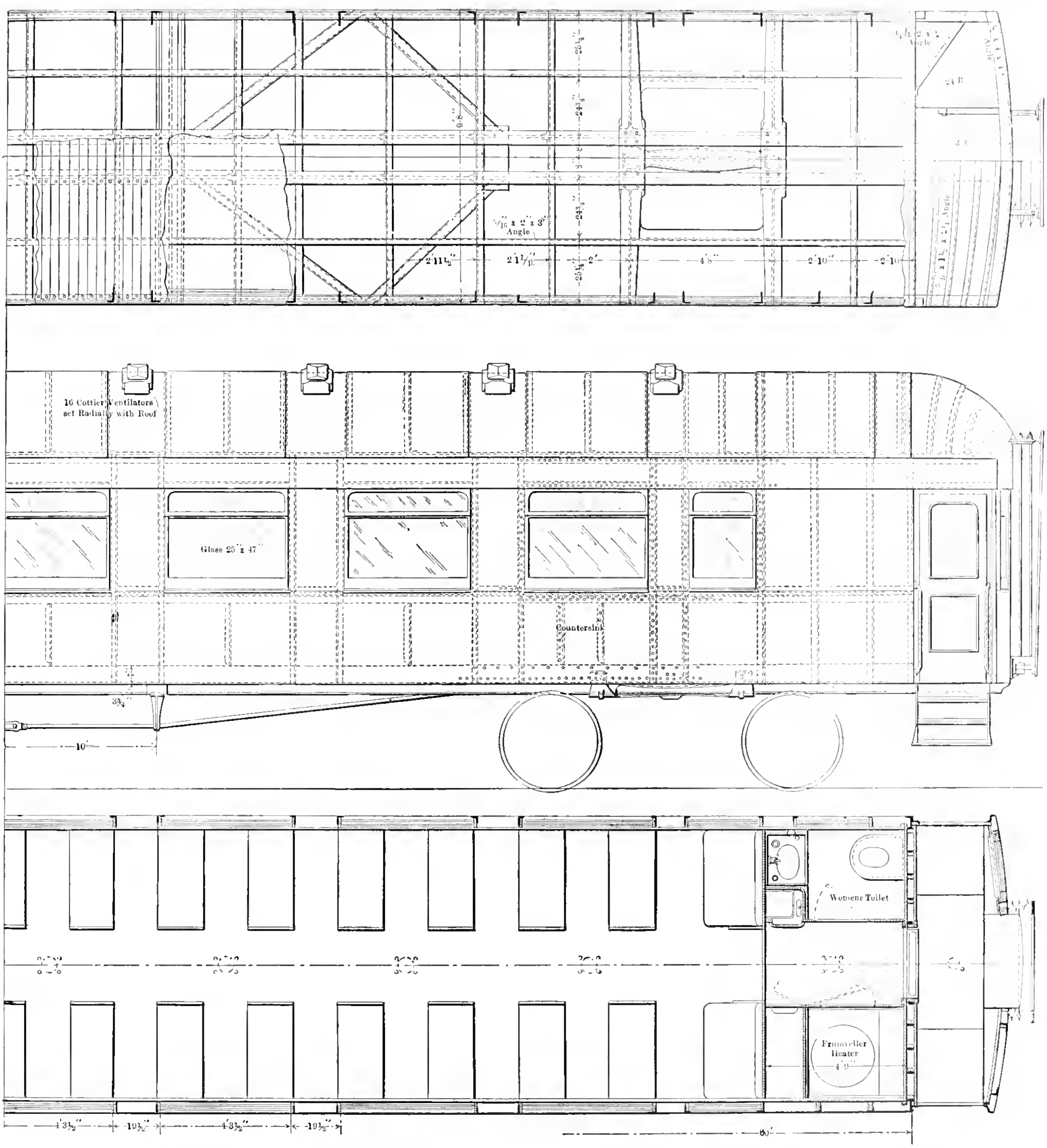
A sample standard, 60 ft., steel coach for the Harriman Lines was recently designed and built by the Southern Pacific Company at the Sacramento shops. The general dimensions and data for this car are as follows:

Length over end sills	59 ft. 10 ins.
Distance between inner faces of coupler knuckles	67 ft. 10 ins.
Distance from centre of body bolster to outside of end sill	8 ft. 10 ins.
Width over side sills	9 ft. 8 ins.
Width over eaves	9 ft. 8¼ ins.
Height top of rail to top of roof	13 ft. 8¼ ins.
Seating capacity	70
Weight of car body	75,500 lbs.
Weight of trucks	31,500 lbs.
Weight, total	107,000 lbs.
Wheels, diameter	36½ ins.
Journals	5 x 9 ins.

The centre sills are 12 in. I beams 31½ lbs. per ft., and are continuous over the platforms. They are reinforced by the 1½ in. truss rods, as shown. The side sills are 3½x7x½ in. angles, the longer leg being placed vertical and riveted to the side sheet. The centre and side sills are tied together between the bolsters by the needle beams and by 6-in. channels, 8 lbs. to the foot, which also answer the purpose of floor supports.

The different members forming the needle beam, consisting of ¼-in. plates, with angles riveted to the edges, as shown, are secured to the sills, and are in addition tied together by the ½x9 in. plate riveted to the angles at the bottom, and extending the full width of the car and by the ¼x7 in. top cover plate.

The 6-in. channels, 8 lbs. per ft., which tie the sills together and carry the longitudinal floor supports are fastened to the centre sill by ¾x2½x2½ in. angles, and to the side sill and



STEEL PASSENGER CAR—HARRIMAN LINES.

posts by angles and gussets, as shown in the drawing. The diagonal braces are 4-in. channels, 5¼ lbs. per ft.

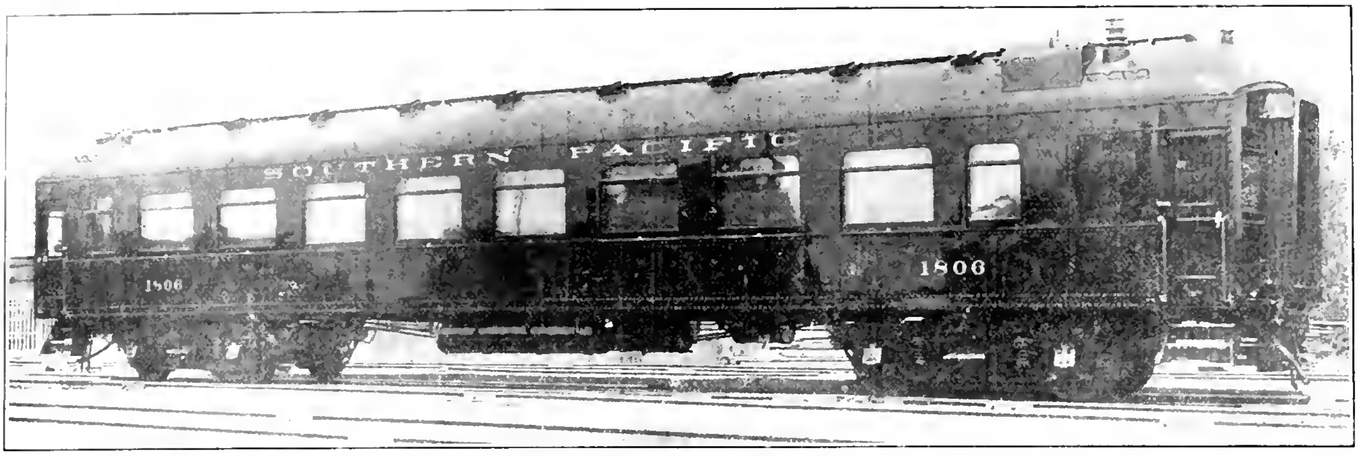
The body bolsters are double and of cast steel. The end sills consist of a ½-in. plate, with 4x4x½ in. angles riveted at the top and bottom, and with a 5-16-in. plate, 20 ins. wide at the centre, riveted to the top angle and to the longitudinal sills.

The arrangement of the steel platform and the Janney coupler attachment is shown on the drawings, except that the coupler is equipped with the standard centering device used by the company. Miner tandem spring draft gear is used.

The floor construction is as follows: The usual wooden nailing strips are not required, as they are replaced by the 5-16x2x3-in. angles, on which is placed a 1-16-in. steel plate as shown; above this is placed a layer of mineral wool, and then a 1½-in. layer of Oregon pine, T and G, 3-in. face. Above this wooden flooring is placed a 1-16-in. steel plate, a 1-16-in. layer of asbestos and a ⅜-in. thickness of linoleum.

The side posts are ⅜x2¼x4 in. angles, with strips of 1¼x 4 1-16 in. yellow pine, bolted to them for securing the inside finish and window sash. The ends of the posts are bent to fit the side sill and side plate angles. The belt rails are ⅜x2¼x4 in. angles fitted between the posts and riveted to them.

The side of the car below the windows is covered with 3-16-in. steel plate, riveted to the posts and butt jointed in three places to permit convenient handling of the plates. Between the windows ⅛-in. plates are riveted to the posts, the ends of these extending under the letter board plate. The letter board is a ⅛-in. steel plate. The construction of the end framing is clearly shown on the drawing. The roof carlines are ¼x 2x3 in. angles, and are riveted to the side plate angles, and have 1⅛x3 in. wood fillers bolted to them for securing the



STEEL PASSENGER CAR—HARRIMAN LINES.

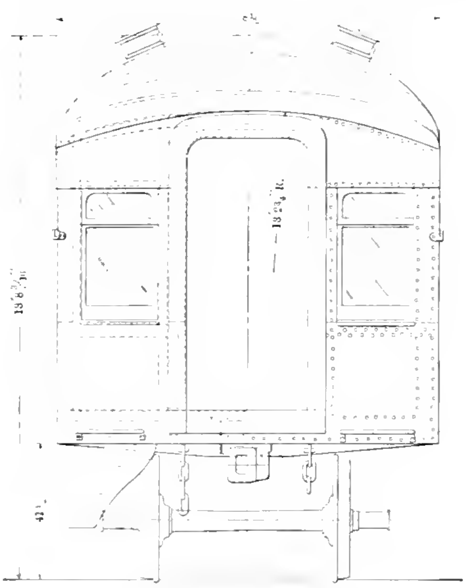
head lining. The roofing consists of 3-32 in. plates. The inside finish is of Mexican mahogany. Cottier ventilators are used. The car is heated by the Consolidated system, in conjunction with a double coil Frumveller heater, and is equipped for lighting either by gas or by the United States (Moskowitz) system of axle electric lighting.

We are indebted for drawings and information to Mr. J. J. Kruttschnitt, director of maintenance and operation of the Harriman Lines.

THE COLLEGE GRADUATE IN PRACTICAL WORK.*

Something may possibly be gained by considering what has seemed to many of the friends of our young graduates to be the one defect which they practically all have in common.

For a period of from six months to two years after graduating they are, generally speaking, discontented and unhappy. They are apt to look upon their employers as unappreciative, unjust and tyrannical, and it is frequently only after changing employers once or twice and finding the same lack of appreciation in all of them that they finally start upon their real careers of usefulness.



END VIEW, STEEL PASSENGER CAR.

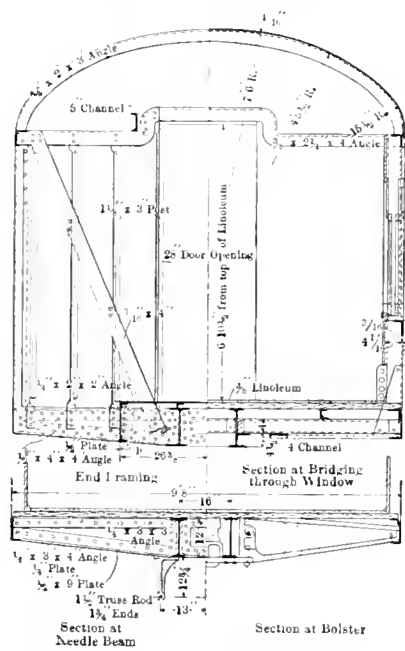
On the other hand, the attitude of employers toward young graduates is fairly expressed by the following written instructions given for the selection of quite a large number of young men to fill positions which presented opportunities for rapid development and advancement. These instructions were to give the preference—first, to graduates of technical schools; second, to the graduates of the academic departments; but to employ no college boy who had not been out for more than two years.

Why is it, then, that these young men are discontented and of practically little use during the first year or two after graduating?

To a certain extent this is unquestionably due to the sudden and radical change from years spent as boys almost solely in absorbing and assimilating knowledge for their own benefit to their new occupation of giving out and using what they have for the benefit of others. To a degree it is the sponge objecting to the pressure of the hand which uses it. To a greater degree, however, I believe this trouble to be due to the lack of discipline and to the lack of direct, earnest and logical purpose which accompanies, to a large extent, modern university life.

During the four years that these young men are at college they are under less discipline and are given a greater liberty than they have ever had before or will ever have again.

As to college discipline, it cannot be a good training for



SECTIONS, STEEL PASSENGER CAR.

after-life for a young man deliberately to be told by the university authorities that he can flagrantly neglect his duties sixty times in one term before any attention will be paid to it; while, if in business, the same young man would be discharged for being absent two or three times without permission.

Of all the habits and principles which make for success in a young man, the most useful is the *determination to do and to do right all of those things which come his way each day, whether they are agreeable or disagreeable;* and the ability to

*Extracts from an address delivered by Mr. Frederick W. Taylor, Pres. Amer Soc. Mech. Eng., at the dedication of the new Engineering Building of the University of Pennsylvania, October 19, 1906.

INTERIOR VIEW OF HARRIMAN LINES STEEL PASSENGER CAR.

do this is best acquired through long practice in doggedly doing, along with that which is agreeable, a lot of things which are tiresome and monotonous, and which one does not like.

As to the object of college life: some boys are sent to the university to learn how to mingle with men and to form friendships which shall prove useful and agreeable in after-life. Some go there to amuse themselves and some to get the standing given by a college degree.

Something can be said for each of these objects. Is not the true object of all education, however, that of training boys to be successful men? I mean, men successful in the broadest sense, not merely successful money getters. Successful, first, in developing their own characters and, second, in doing their full share of the world's work.

Young men should not come to college mainly to get book-learning or a wide knowledge of facts. The successful men of our acquaintance are, generally speaking, neither learned, nor men of great intellect. They are men, first of all, possessed with an earnest purpose. They have a certain all-round poise, or balance, called common sense. They have acquired, through long training, those habits, both mental and physical, which make them masters over themselves; and at all times they have the firm determination to pay the price for success in hard work and self-denial.

. . . .

Is not the greatest problem in university life, then, how to animate the students with an earnest logical purpose?

In facing this question, I would call attention to one class of young men who are almost universally imbued with such a purpose, namely, those who, through necessity or otherwise, have come into close contact and direct competition with men working for a living. These young men acquire a truly earnest purpose. They see the reality of life; they have a strong foretaste of the struggle ahead of them, and they come to the university with a determination to get something practical from the college training which they can use later in their competition with men.

They are in great demand after graduating, and, as a class, make themselves useful almost from the day that they start in to work.

. . . .

I look upon this actual work and competition with men working for a living as of such great value in developing earnestness of purpose that it would seem to me time well spent for each student, say, at the end of the Freshman year, to be handed over by the university for a period of six months to some commercial, engineering or manufacturing establishment—there to work as an employe at whatever job is given him, either manual or other work. He should have the same hours and be under the same discipline as all other employes, and should receive no favors. Moreover, he should be obliged to stay even a longer time than six months, unless he has, in the meantime, given satisfaction to his employers.

. . . .

My belief in the benefits to be derived from doing practical everyday work early in the college course is not the result of a theory. It is founded upon close observation and study of young men who have had this experience, and also upon a vivid remembrance of breakfasting each morning at 5: 30 and starting to sweep the floor of a pattern shop as an apprentice some thirty-two years ago, after having spent several years in preparing for Harvard College. The contrast between the two occupations was great, but I look back upon the first six months of my apprenticeship as a pattern-maker as on the whole the most valuable part of my education. Not that I gained much knowledge during that time, nor did I ever become a good pattern-maker; but the awakening as to the reality and seriousness of life was complete and, I believe, of great value.

Unfortunately, laboratory or even shop work in the university, useful as they are, do not serve at all the same purpose, since the young man is surrounded by other students and professors and lacks the actual competition of men working for a living. He does not learn at college that, on the whole, the ordinary mechanics and even poorly educated workmen are naturally about as smart as he is and that the best way to rise above them lies in getting his mind more thoroughly trained than theirs and in learning things they do not know. All of this should be taught him through six months' contact with workingmen.

Let me repeat, in conclusion, that our college graduates are the best picked body of men in the community. Yet I believe that it is possible to so train young men that they will be useful to their employers almost from the day that they leave college, so that they will be reasonably satisfied with their new work instead of discontented, and to place them, upon graduating, one of two years nearer success than they now are, and that this can be best accomplished by giving them an earnest purpose through six months' contact early in their college life with men working for a living by rigidly prescribing a course of studies, carefully and logically selected, and with some definite object in view, and by subjecting them to a discipline comparable with that adopted by the rest of the world.

TOOL ROOM CARE AND ECONOMY.

MR. F. G. DE SAUSSURE.*

Although there is more or less truth in the old saying that "Any man can do good work with good tools, but it takes a good man to do good work with poor tools," still it is self-evident that the philosopher was not a product of the twentieth century shop, for, had he known the modern rush or worked under a "piece-work system," he would have seen that good tools are as essential to an organization as is good material, and that the tool room is the very heart of the modern shop body.

Much attention has been given to material, but the care of tools is woefully lacking in most of our large plants and systems, and yet a saving of expenses in this department is easily accomplished.

For the tool room foreman to care for the tools, it is necessary for him to know at all times the location of any particular tool, whether in service, under repairs or on the rack, and to gain this information a checking system must be installed—one that will cover at least four points: (1) Tools in service; (2) tools under repair; (3) tools ordered; (4) tools to be ordered. But, to have a checking system, it stands to reason that each tool belonging to the shop must have a separate and distinct place in the tool room and that its name, size or number be clearly stenciled under its place in the rack. There are numerous forms of racks, upon which the smaller tools, such as drills, taps, etc., may be kept, some conical in form, flat shelves or pigeon holes; but, for economy of space and simplicity, the slanting rack, as shown in Fig. 1, is probably the best. These racks are cheap in construction, durable and clean; no cupboards as dirt collectors, and can be placed wherever most convenient.

Upon the facing strips of these racks the name and size of the tool should be clearly stenciled (yellow cromine letters upon a black background making a good combination), and to do this, strips of bright tin cut 2 ins. wide are lampblacked, and the letters then stencilled upon them. The reason for using tin instead of painting upon the board itself is two-fold: a better surface and easier for the painter.

An easy method of laying out these tins is as follows: Take a roll of ordinary wrapping paper and saw 2 ins. off the end, thus giving a slip of paper 2 ins. wide and several hundred feet in length. Stretch these slips across the facing pieces of the rack and mark in lead pencil the size of the tool and space required. It is now easy for the painter to duplicate this upon the tin strips, and allows him to paint with them upon a table, insuring a quicker and better job than if he had to do the work with the tins previously nailed upon the racks.

After all tools are thus taken care of, the rules to keep them in their proper places cannot be too strict. It certainly would be of no advantage to provide a place for each tool and then to allow them to be thrown upon the floor or put up in the wrong rack.

The shop management has a choice in the checking system of whether the men shall carry their own checks or have them taken care of in the tool room. Experience compels the writer to say that, where the checks are carried by the men many complications will arise, checks left at home, lost, borrowed, stolen, and the interchange of check for tool other than at the tool room window. The first cost of taking care of the checks in the tool room is probably a little greater than when every man is given his bunch of checks, but its simplicity and accuracy soon pays for the cost of construction of a check rack.

APPEARANCE OF TOOL RACK.

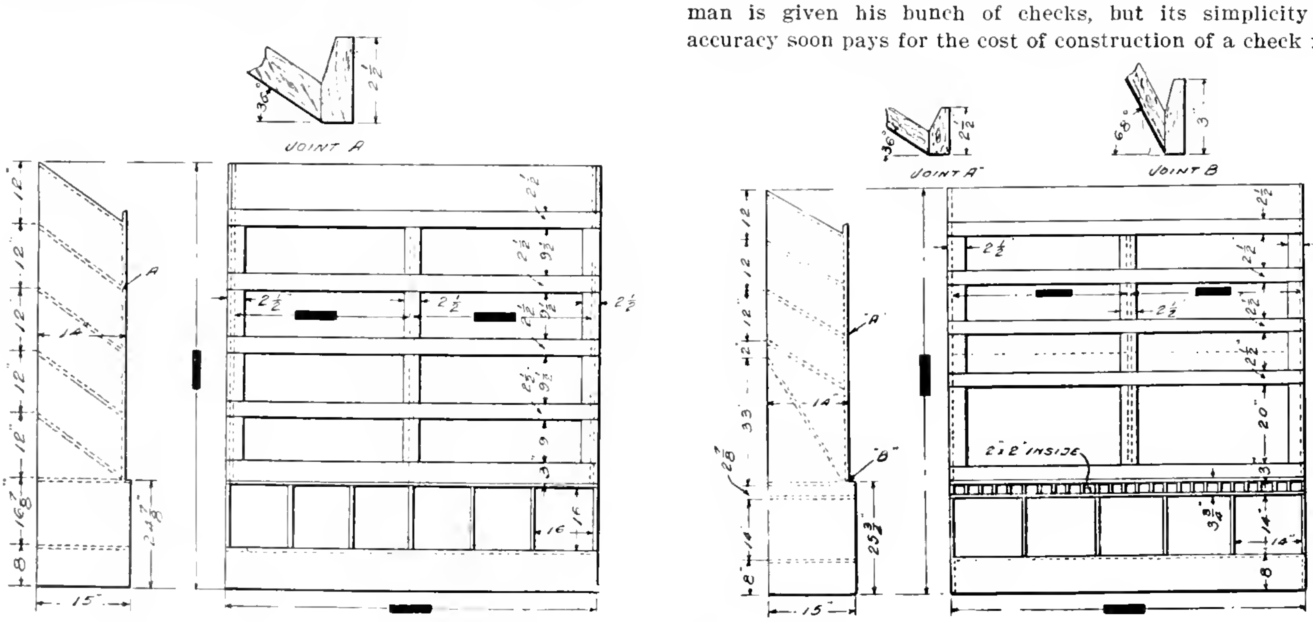


FIG. 1.—DETAILS OF TWO ARRANGEMENTS OF TOOL RACK.

A careful study of the check rack illustrated in Fig. 2 will show that the name of every employe is placed opposite a small pigeonhole containing twelve tin checks, say ⅝ x 1¼ ins. Each check (Fig. 3) has a small hole punched in one end, so that it may be hung upon a brad driven opposite the stenciled size of each tool. The employe's name is typewritten upon heavy paper, and this paper then cut into strips ¾ x 2 ins. and

*Erie Railroad Company.

the pieces placed between the edges of the folded tin receivers that are fastened to the name panel.

The continual shift of men in larger plants makes it necessary to keep changing the names from time to time, and, that the tool room foreman may keep posted and have his rack up-to-date, it would be well to adapt a form something similar to the following for the men employed:

> TO THE TOOL ROOM FOREMAN.—The bearer Mr............................has this day been employed by the Co., please give him a tool check number.
>
> ....
> Gen'l Foreman.
>
> ....
> ....
> (Typewrite here name of man employed.)

and for men leaving the service:

> TO THE TOOL ROOM FOREMAN.—The bearer Mr.............................is this day leaving the Co.'s employ, kindly O. K. his checks and return.
>
> ....
> Gen'l Foreman.
>
> ....
> Tool Room Foreman.

The object of repeating the name of the man employed is that in the tool room this bottom name may be cut out and placed in the rack.

The racks themselves may be square, hexagonal or octagonal, according to the number of men employed, should be made of light material and have one side, or face, hinged to act as a door. To remove or replace a name, open the door, turn the thumb catches down, remove panel to inside of rack and take out or slip in name between edges of folded tin.

Let us now illustrate the system by following a tool. The employe, John Smith No. 98, comes to the delivery window and wishes the ¾ in. standard taps. The tool boy takes check No. 98 from the pigeonhole as he passes toward the tap rack, hangs it on the brad opposite ¾ in. "Standard Taps" and

FIG 3.

delivers the tools to Smith at the window. When the tools are returned, the check is again placed in the pigeonhole opposite Smith's name, or No. 98, and the tools placed on the rack in their allotted space.

To cover the four points enumerated above as being essential to a good checking system, the foreman should have on hand, say, fifty checks of the ordinary size painted blue, fifty painted red, and fifty painted yellow. A small blue print (Fig. 6), framed and hung in the tool room, will explain the use of these colored checks. Thus: John Smith brings back the ¾ in. standard taps, and one of them is broken. It cannot be used again, and so its place is vacant. If it can be repaired, hang a yellow check in the place of Smith's, again placing his in the pigeonhole, and place the tool under repairs as soon as practicable. If it cannot be repaired, place a red check and replace the broken taps with a new set from stock, thus keeping the rack full, and check out when called for, just as if the red check was not there. When ordered on either special or regular requisition, place the blue check on the brad. The difference between the "To be Replaced" and the "On Requisition" is readily seen to prevent the same tool being ordered on two requisitions. This method of checking enables the foreman to tell at a glance just where all tools are and what should be ordered to replace those broken or lost.

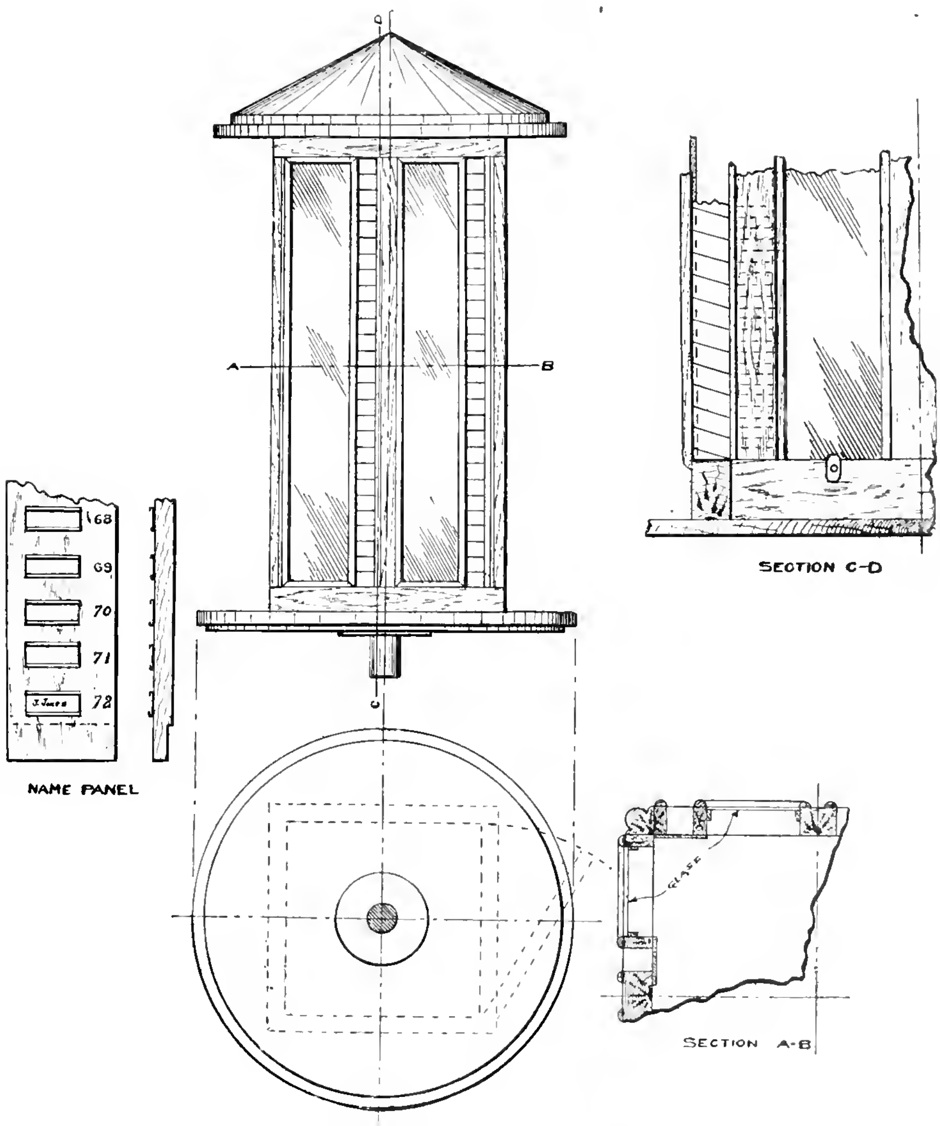


FIG. 2.—DETAILS OF CHECK RACK.

APPEARANCE OF CHECK RACK.

The tool room foreman should number all air hammers, air motors, jacks and tools of that kind, and a board (Fig. 4) should be placed near the delivery window, and the hammers, motors, etc., checked out in the usual manner, only the checks being hung upon the board, since the hammers are kept in an oil bath and the motors on a rack made of iron pipe, where it would be difficult to have brads opposite the tools.

It often is the case, especially in the larger plants, that more than one tool room is required. Take, for instance, a manufacturing concern in which the boiler shop is located some distance from the machine department. It would be an utter waste of time for a boiler-maker to be compelled to go to the machine department tool room for every tool that he might require, and it would surely be economy to have a small tool room in the boiler shop and equip it with such tools as are most used in boiler making. But it would be impracticable to give both shops an elaborate equipment, and for this reason some means of interchange between the two places must be established which will avoid the error of having an undue number of toolmakers, and yet provide ample facilities for the proper care of all tools and not complicate matters so that it is hard for the workman to secure whatever tool he may desire.

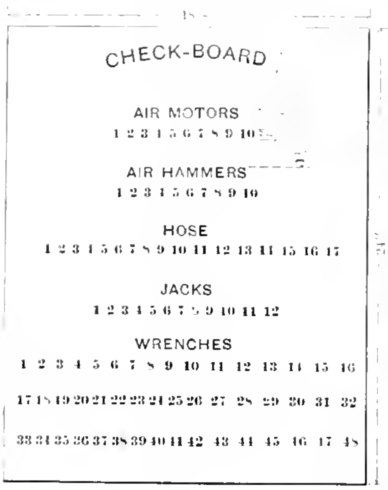


FIG. 4.

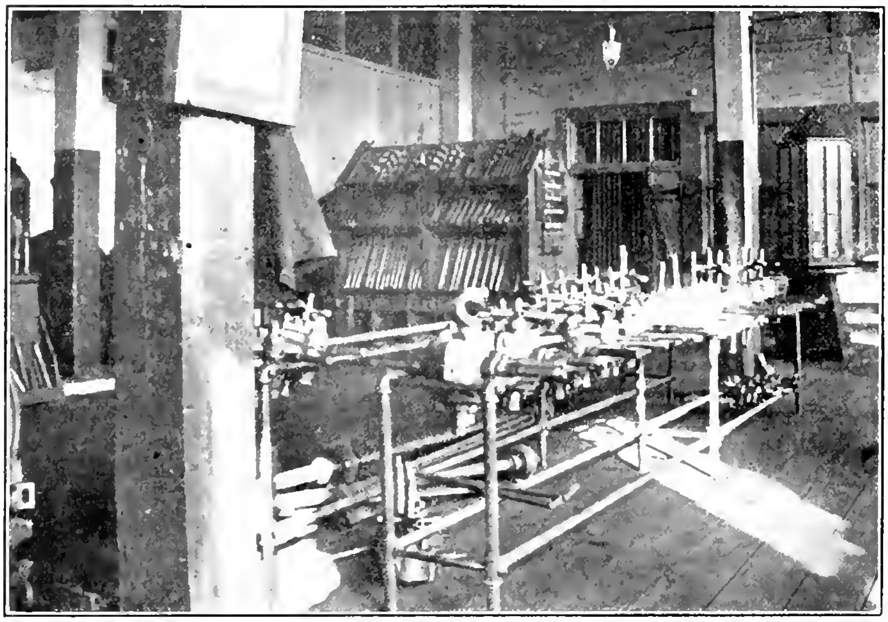


FIG. 5—RACK FOR AIR MOTORS.

To reduce the number of toolmakers, establish one place as the main tool room and have all tools in need of repairs or to be made brought to the foreman of that place, and give that foreman charge over both tool rooms, so that there may be a clearly defined head and someone to whom all business pertaining to that department may be referred. To prevent the carrying of the boiler-makers' names in the machine department tool room and the consequently large rack, an exchange check should be used. Thus, a boiler-maker desiring a tool not kept in his department goes to the delivery window, and his check is taken from the pigeonhole and placed on a board in the place of a similar check marked "Boiler Shop Exchange," or simply "B. S. Exc." and with this exchange check he is entitled to any tool from the main tool room. When he has finished using the tool, he takes it back to the main tool room, receives the exchange check back, which, when taken to the boiler shop delivery window, will be again changed for his check, which is now replaced in the pigeonhole. This has the double advantage of keeping the men under their own department and at the same time protects the main tool room.

NAME OF SYSTEM.
Report of Broken Tools.
Date..
Tool Broken..
Broken By..
Remarks...
....
....
APPROVED.
....
T. R F'man. Gen'l F'man. Mast. Mech.

FIG. 7.

There cannot be too much said about broken tools, but it will suffice to say that, although many tools are broken through no fault of the operator, still it is safe to say that there are quite a number damaged through carelessness, and it is another case of the innocent suffering with the guilty. There should be a record kept of broken tools, similar to that shown in Fig. 7, and this record should be forwarded to the shop foreman and a careful investigation made, for it is only through some such system that the condition of the machine, as well as the carelessness of the employe, may be checked.

On some of the larger railroad systems there are many special tools made at the different shops and used locally, but these tools are a long time finding their way into more distant shops, and for the purpose of having them in general service a "Book of Special Devices" should be made up at the head office. Each master mechanic should be furnished with one of these books, and, as a special tool is made, a drawing of it should be made and blue prints from this drawing sent to the master mechanics for their book, and tool room foremen should be at once authorized to construct these tools and place them in service.

KEY TO COLORS

WHITE	IN SERVICE
BLUE	ON REQUISITION
RED	TO BE REPLACED
YELLOW	UNDER REPAIRS

FIG 6.

But above all (and, I might say, the writer's hobby) is the question of a standard, and the reader will pardon a rather bold statement when I say that there should be no special tools, or, more correctly, no odd thread taps—no taps ranging in sixty-fourths or even thirty-seconds. If it is found that a certain class of engine needs a certain tap for its grease cup or crank-pin nut, then make that into a special device and have it a standard for the entire system. If a hole needs to be tapped in thirty-seconds, a shim of tin placed by the tap will answer all purposes. This thing of every shop having its own ideas as to what thread a certain nut should have, and no

other shop having the same thread tap, is entirely wrong and very expensive. All taps of a size should have the same size heads (as large as the stock will permit). All reamers of the same class should have the same taper per inch, the double and single end wrenches should fit the squares; "Morse tapers" should not be ground by hand on an emery wheel, and many other things too numerous to mention, but which, if permitted, will make a waste that would bankrupt the best of firms.

The questions of light, heat and size of shop make it impossible for the writer to give any definite statements or drawings as regards to the tool room layout, and so that part of the matter will be left to be governed by local conditions. One thing, however, should always be remembered, and that is that cleanliness is of the greatest importance, and, with this end in view, do not make your tool room into a storehouse nor yet into a junk pile.

HIGH STEAM PRESSURE IN LOCOMOTIVE SERVICE.*

BY DR. W. F. M. GOSS.

The Carnegie Institution of Washington, D. C., some three years since, became a patron of Purdue University for the purpose of promoting a research to determine the value of high steam pressures in locomotive service. The work outlined under these auspices has now been completed, and final report has been rendered the Institution. This report will soon be published. Meantime, the Institution has given its consent to the publication of a preliminary statement concerning methods and results.

1. *The Tests.*—The tests outlined included a series of runs, for which the average pressure was respectively 240, 220, 200, 180, 160, 120 lbs., a range which extends far below and well above pressures now common in locomotive service. The tests of each series were to be sufficiently numerous to define completely the performance of the engine when operated at any speed and for all positions of the reverse lever possible with a wide-open throttle. So far as practicable, each test was to be of sufficient duration to permit the efficiency of engines and boiler to be accurately determined, but where this could not be done, cards were to be taken.

The first test was run February 15, 1904, and the last August 7, 1905. A registering counter attached to the locomotive shows that between these dates the locomotive drivers made 3,113,333 revolutions, which is equivalent to 14,072 miles. The completed record includes the data of 100 different tests.

2. *The Locomotive* upon which the tests were made is that regularly employed in the laboratory of Purdue University, where it is known as "Schenectady No. 2." The characteristics of this locomotive are rather generally known.

3. *Difficulties in Operating Under High Pressures.*—The work with the experimental locomotive has shown that those difficulties which, in locomotive operation, are usually ascribed to bad water, increase rapidly as the pressure is increased. The water supply of the Purdue laboratory contains a considerable amount of magnesia and carbonate of lime. When used in boilers carrying low pressure there is no great difficulty in washing out practically all sediment. The boiler of the first experimental locomotive, Schenectady No. 1, which carried but 140 lbs. and was run at a pressure of 130 lbs., after serving in the work of the laboratory for a period of six years, left the testing plant with a boiler which was practically clean. Throughout its period of service this boiler rarely required the attention of a boilermaker to keep it tight. Water from the same source was ordinarily used in the boiler of Schenectady No. 2, which carried a pressure of 200 lbs. or more. It was early found that this boiler, which is of the same general dimensions as that of Schenectady No. 1, operating under the higher pressure, frequently required the attention of a boilermaker. After having been operated no more than 30,000 miles, cracks developed in the side sheets, making it impossible to keep the boiler tight, and new side sheets were applied. In operating under pressures as high as 240 lbs., the temperature of the water delivered by the injector was so high that scale was deposited in the check valve, in the delivery pipe and in the delivery tube of the injector. Under this pressure, with the water normal to the laboratory, the injectors often failed after they had been in action for a period of two hours. The loss of tests through failure of the injector, and through the starting of leaks at stayholts, as the tests proceeded, became so annoying that, as a last resort, a new source of water supply was found in the return tank of the University heating plant. This gave practically distilled water, and its use greatly assisted in running the tests at 240 lbs. pressure.

Probably some of the difficulties experienced in operating under very high steam pressures were due to the experimental character of the plant, and would not appear after practice had by gradual process of approach become committed to their use, but the results are clear in their indication that the problem of boiler maintenance, especially in bad water districts, will become more complicated as pressures are further increased. Since, taking the country over, there are few localities where locomotives can be furnished with pure water, the conclusion stated should be accepted as rather far-reaching in its effect.

The test developed no serious difficulties in the lubrication of valves and pistons under pressures as high as 240 lbs., though the lubrication could not be done with a grade of oil previously employed.

With increase of pressure, any incidental leakage, either of the boiler or from cylinders, becomes more serious in its effect upon performance. In advancing the work of the laboratory, every effort was made to prevent loss from such causes, and results were frequently thrown out and tests repeated because of the development of leaks of steam around piston and valve rods, or of water from the boiler. Notwithstanding the care taken, it was impossible under the higher pressures to prevent all leakage, and the best that can be said for the data under these conditions is that it represents results which are as free as practical from irregularities arising from the causes referred to; that is, so far as leakage may affect performance, the results of the laboratory tests may safely be accepted as the record of maximum performance.

In concluding this brief review of the difficulties encountered in the operation of locomotives under very high steam pressures, the reader is reminded that an increase of pressure is an embellishment to which each detail in the design of the whole machine must give a proper response. A locomotive which is to operate under such pressure will need to be more carefully designed and more perfectly maintained than a similar locomotive designed for lower pressure, and much of that which is crude and imperfect, but nevertheless serviceable in the operation of locomotives using a lower pressure, must give way to a more perfect practice in the presence of the higher pressure.

4. *The Effect of Different Pressures upon Boiler Performance* is summarized as follows:

1. The evaporate efficiency of a locomotive boiler is but slightly affected by changes in pressure, between the limits of 120 lbs. and 240 lbs.

2. Changes in steam pressure between the limits of 120 lbs. and 240 lbs. will produce an effect upon the efficiency of the boiler which will be less than ½ lb. of water per pound of coal.

3. The equation $E=11.305-.221\ H$, in which E is the number of pounds evaporated from and at 212 deg. per pound of coal, and H is the ponnds of water evaporated per foot of heating surface per hour, represents the evaporative efficiency of the boiler of locomotive Schenectady No. 2 when fired with Youghiogheny coal for all pressures between the limits of 120 lbs. and 240 lbs. with an average error for any pressure which does not exceed 2.1 per cent.

4. It is safe to conclude that changes of no more than 40 or 50 lbs. in pressure will produce no measurable effect upon the evaporative efficiency of the modern locomotive boiler.

*A brief extract of a report submitted to the Carnegie Institution of Washington, August 17, 1906. Read at the November meeting of the Western Railway Club.

5. The effect of different pressures upon smokebox temperatures was found to be as follows:

1. The smokebox temperature falls between the limits of 590 deg. F. and 850 deg. F., the lower limit agreeing with a rate of evaporation of 4 lbs. per foot of heating surface per hour, and the higher with a rate of evaporation of 14 lbs. per foot of heating surface per hour.

2. The smokebox temperature is so slightly affected by changes in steam pressure as to make negligible the influence of such changes in pressure for all ordinary ranges.

3. The equation $T = 488.5 + 25.66\ H$, where T is the temperature of the smokebox and H is the weight of water evaporated from and at 212 deg. per foot of heating surface per hour, possesses a high degree of accuracy for all ordinary pressures.

6. *The Engine Performance.*—The shaded zone upon Fig. 1 represents the range of performance as it appears from all tests run under the several pressures employed. It shows that the variation in performance for all conditions of running which are possible with a wide-open throttle scarcely exceeds 5 lbs. For purposes of comparison, it is desirable to define the effect of pressure on performance by a line, and to this end an attempt has been made to reduce the zone of performance to a representative line. In preparing to draw such a line, the average performance of all tests at each of the different pressures was obtained and plotted, the results being shown by the circles on Fig. 1. Points thus obtained can be regarded as fairly representing the performance of the engine under the several pressures only so far as the tests run for each different pressure may be assumed to fairly represent the range of speed and cutoff under which the engine would ordinarily operate. The best results for each different pressure as obtained by averaging the best results for each speed at this pressure is given upon the diagram in the form of a light cross. These points may be regarded as furnishing a satisfactory basis of comparison in so far as it may be assumed

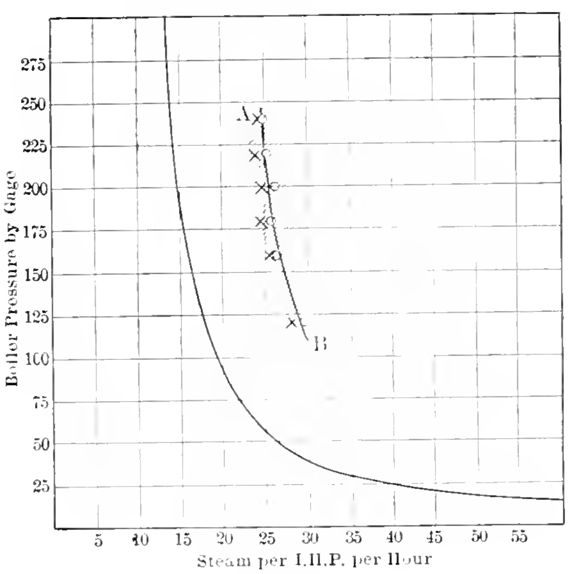


FIG. 1.

that when the speed has been determined an engine in service will always operate under conditions of highest efficiency. Again, the left-hand edge of the shaded zone represents a comparison based on maximum performance at whatever speed or cutoff.

In addition to the points already described, there is located upon the diagram Fig. 1 a curve showing the performance of a perfect engine, with which the plotted points derived from the data of tests may be compared.* Guided by this curve representing the performance of a perfect engine, a line A B has been drawn proportional thereto and so placed as to fairly represent the circular points derived from the experiments. It is proposed to accept this line as representing the steam consumption of the experimental engine under the several pressures employed. It is to be noted that it is not the minimum performance nor the maximum, but it is a close approach to that performance which is suggested by an average of all results derived from all tests which were run. Since its form is based upon a curve of perfect performance, it has a logical basis and, since it does no violence to the experimental data, it seems to be justifiable.

7. *Coal Consumption.*—Accepting the curve A B, Fig. 1, as fairly representing the consumption of steam, the corresponding consumption of Youghiogheny lump coal for the several pressures employed is shown by the following table:

	Coal		
		Saved for each increment of pressure	
	Per I. H. P., per hour.	Pounds.	Per cent.
240 lbs. boiler pressure........	3.31	....	...
220 lbs. boiler pressure........	3.35	0.04	1.2
200 lbs. boiler pressure........	3.40	.05	1.5
180 lbs. boiler pressure........	3.46	.06	1.7
160 lbs boiler pressure........	3.53	.07	2.0
140 lbs. boiler pressure........	3.67	.14	3.8
120 lbs. boiler pressure........	3.84	.17	4.4

The last two columns of the preceding table show the diminishing value of the fuel saving which results from a given increment of pressure as the scale of pressure is ascended. For example, increasing the pressure from 120 to 140 lbs. results in a full saving of 4.4 per cent., while a similar increment from 220 to 240 lbs. results in a saving of but 1.2 per cent.

8. *Increased Boiler Capacity as an Alternative for Higher Pressures.*—Previous publications from the Purdue laboratory have shown the possibility, under certain conditions, of securing a substitute for very high boiler pressures in the adoption of a boiler of larger capacity, the pressure remaining unchanged. If, for example, in designing a new locomotive, it is found possible to allow an increase of weight in the boiler as compared with that of some older type, it becomes a question as to whether this possible increase of weight should be utilized by providing a higher pressure or for an increase in the extent of heating surface. The results of tests supplemented by facts concerning the weight of boilers designed for different pressures and for different capacities supply the data necessary for an analysis of this question.

The full report presents with great elaborateness the facts which underlie the analysis. The results derived are well shown in Fig. 2, in which the full line curves represent the gain through the increase of boiler pressure and the dotted line the corresponding gain through the increase of boiler capacity. It will be seen that, starting with pressures which are compartively low, the most pronounced benefits are those to be derived from increments of pressure. With each rise in pressure, however, the chance for gain through further increase diminishes. With a starting point as high as 180 lbs., the saving through increased pressure is but slightly greater than that which may result through increased boiler capacity. For still higher pressures, the argument is strongly in favor of increased capacity.

The fact should be emphasized that the conclusions above described are based upon data which lead back to the question of coal consumption. The gains which are referred to are measured in terms of coal which may be saved in the development of a given amount of power. It will be remembered that conditions which permit a saving in coal will, by the sacrifice of such a saving, open the way for the development of greater power, but the question as defined is one concerning economy in the use of fuel. It is this question only with which the diagrams, Fig. 2, deal.

There are other measures which may be applied to the performance of a locomotive, which, if employed in the present case, would show some difference in real values of the two curves, A and B (Fig. 2). The indefinite character of these measures prevent them being directly applied as corrections to the results already deduced, but their effect may be pointed

*This curve represents the performance of an engine working on Carnot's cycle, the initial temperature being that of steam at the several pressures stated, and the final temperature being that of steam at 1.3 lbs. above atmospheric pressure. This latter value is the assumed pressure of exhaust in locomotive service.

out. Thus the extent to which an increase of pressure will improve performance has been defined, but the definition assumes freedom from leakage. If, therefore, leakage is allowed to exist, the result defined is not secured. Moreover, an increase of pressure increases the chance of loss through leakage, so that to secure the advantage which has been defined there must be some increase in the amount of attention bestowed, and this in whatever form it may appear means expense, the effect of which is to reduce the net gain which it is possible to derive through increase of pressure. Again, in parts of the country where the water supply is bad, any increase of pressure will involve increased expense in the more careful and more extensive treatment of feed-water, or in the increased cost of boiler repairs, or in losses arising from failure of injector, or from all of these sources combined. The effect of such expense is to reduce the net gain which it is possible to derive through increase of pressure. In view of these statements, attention should be called to the fact that the gains which have been defined as resulting from increase of pressure (Fig. 2) are to be regarded as the maximum gross; as maximum because they are based upon results derived from a locomotive which was at all times maintained in the highest possible condition, and as gross because on the road conditions are likely to be introduced which will necessitate deductions therefrom.

On the other hand, the relation which has been established, showing the gain to be derived through increased boiler capacity, is subject to but few qualifying conditions. It rests upon the fact that, for the development of a given power, a large boiler will work at a lower rate of evaporation per unit area of heating surface than a smaller one. The saving which results from diminishing the rate of evaporation is sure, whether the boiler is clean or foul, tight or leaky, or whether the feed-water is good or bad, the reduced rate of evaporation will bring its sure return in the form of increased efficiency. An increase in the size of a boiler will involve some increase in the cost of maintenance, but such increase is slight and of a sort which has not been regarded in the discussion involving boilers designed for higher pressure. Remembering, then, that as applied to conditions of service the line A is likely to be less stable in its position than B, the facts set forth in Fig. 2 may be briefly reviewed.

Basing comparisons upon an initial pressure of 120 lbs. (Fig. 2), a 5 per cent. increase in weight when utilized in securing a stronger boiler will improve the efficiency 8.5 per cent., while, if utilized in securing a larger boiler, the improvement will be a trifle less than 3 per cent. Arguing from this base, the advantage to be derived from an increase of pressure is great. If, however, the increase in weight exceeds 10 per cent, the curve A ceases to diverge from B, and if both curves are sufficiently extended, they will meet, all of which is proof of the fact that the rate of gain is greatest for relatively small increments of weight.

Basing comparisons upon an initial pressure of 140 lbs. (Fig. 2), the relative advantage of increasing the pressure, diminished though on the basis of a 5 per cent. increase in weight, is still double that to be obtained by increasing the capacity.

Basing comparisons upon an initial pressure of 160 lbs. (Fig. 2), the advantage to be gained by increasing the pressure over that which may be had by increasing the capacity is very slight, so slight, in fact, that a little droop in the curve of increased pressure (A) will cause the difference to disappear. As the curve B may be regarded as fixed, while A, through imperfect maintenance of boiler or engine, may fall, the argument is not strong in favor of increasing pressure beyond the limit of 160 lbs.

Basing comparisons upon an initial pressure of 180 lbs. (Fig. 2), the advantage under ideal conditions of increasing the pressure as compared with that resulting from increasing the capacity, has a maximum value of approximately one-half of one per cent. In view of the incidental losses upon the road, the practical value of the apparent advantage is nil. In view of what has been said with reference to the stability of the curves A and B, Fig. 2, constitutes no argument in favor of increasing pressure beyond the limit of 180 lbs.

Basing comparisons upon an initial pressure of 200 lbs. (Fig. 2), it appears that, under ideal conditions, either the pressure or the capacity may be increased with equal advantage, which, in effect, is a strong argument in favor of increased capacity rather than of higher pressure.

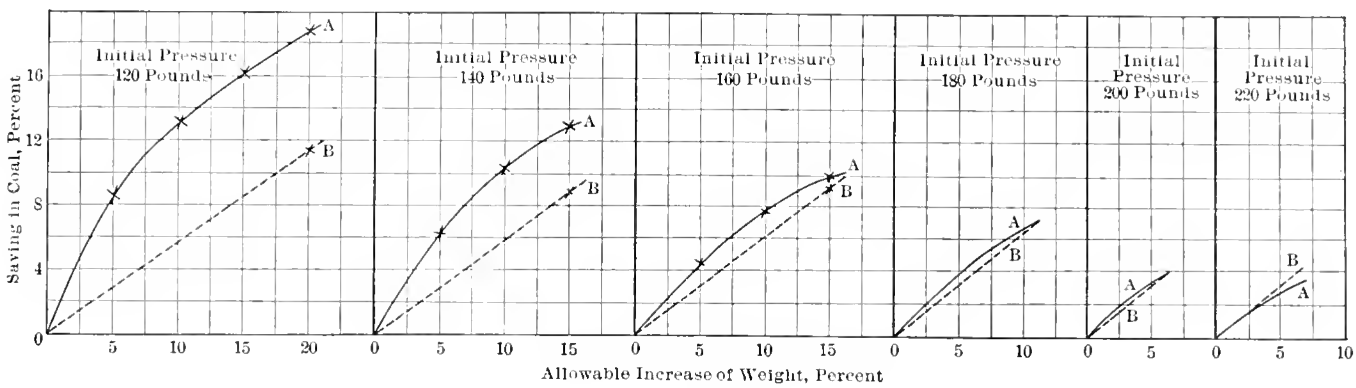


FIG. 2.

Basing comparisons upon a pressure of 220 lbs. (Fig. 2), it appears that even under ideal conditions of maintenance the gain in efficiency resulting from an increase of pressure is less than that resulting from an increase of capacity. In view of this fact, no possible excuse can be found for increasing pressure above the limit of 220 lbs.

8. *Conclusions.*—A summary of the whole work may be stated as follows:

1. Tests have been made to determine the performance of a typical locomotive when operating under a variety of conditions with reference to speed, power and steam pressure. The results of 100 such tests have been made of record.

2. The results apply only to practice involving single expansion locomotives using saturated steam. They cover only such conditions as may be maintained with wide-open throttle. Pressures specified are to be accepted as running pressures. They are not necessarily those at which safety valves open.

3. The steam consumption under normal conditions of running has been established as follows:

	Steam per H.P. hr.
120 lbs. boiler pressure..	29.1
140 lbs. boiler pressure..	27.7
160 lbs. boiler pressure..	26.6
180 lbs. boiler pressure..	26.0

	Steam per H.P. hr.
200 lbs. boiler pressure..	25.5
220 lbs. boiler pressure..	25.1
240 lbs. boiler pressure..	24.7

4. The results show that the higher the pressure, the smaller the possible gain resulting from a given increment of pressure. An increase of pressure from 160 to 200 lbs. results in a saving of 1.1 lbs. of steam per horsepower hour, while a similar change from 200 lbs. to 240 lbs. improves the performance only to the extent of .8 of a lb. per horsepower hour.

5. The coal consumption under normal conditions of running has been established as follows:

	Coal per H.P. hr.		Coal per H.P. hr.
120 lbs. boiler pressure..	3.84	200 lbs. boiler pressure..	3.40
140 lbs. boiler pressure..	3.67	220 lbs. boiler pressure..	3.35
160 lbs. boiler pressure..	3.53	240 lbs. boiler pressure..	3.31
180 lbs. boiler pressure..	3.46		

6. An increase of pressure from 160 to 200 lbs. results in a saving of 0.13 lbs. of coal per horsepower hour, while a similar change from 200 to 240 results in a saving of but 0.09 lbs.

7. Under service conditions, the improvement in performance with increase of pressure will depend upon the degree of perfection attending the maintenance of the locomotive. The values quoted in the preceding paragraphs assume a high order of maintenance. If this is lacking, it may easily happen that the saving which is anticipated through the adoption of higher pressures will entirely disappear.

8. The difficulties to be met in the maintenance both of boiler and cylinders increase with increase of pressure.

9. The results supply an accurate measure by which to determine the advantage of increasing the capacity of a boiler. For the development of a given power, any increase in boiler capacity brings its return in improved performance without adding to the cost of maintenance, or opening any new avenues for incidental losses. As a means of improvement, it is more certain than that which is offered by increase of pressure.

10. As the scale of pressure is ascended, an opportunity to further increase the weight of a locomotive should, in many cases, find expression in the design of a boiler of increased capacity rather than in one for higher pressures.

11. Assuming 180 lbs. pressure to have been accepted as standard, and assuming the maintenance to be of the highest order, it will be found good practice to utilize any allowable increase in weight by providing a larger boiler rather than by providing a stronger boiler to permit higher pressures.

12. Whenever the maintenance is not of the highest order, the standard running pressures should be below 180 lbs.

13. Wherever the water which must be used in boilers contains foaming or scale-making admixtures, best results are likely to be secured by fixing the pressure below the limit of 180 lbs.

14. A simple locomotive, using saturated steam, will render good and efficient service when the running pressure is as low as 160 lbs.; under most favorable conditions, no argument is to be found in the economical performance of a machine which can justify the use of pressures greater than 200 lbs.

Cost of Incandescent Lamps.—In the beginning of the career of the incandescent electric lamp about 75 cents worth of platinum was used in a single lamp, and the bulb was blown by hand from a piece of tubing. At the present time the platinum in a lamp costs about ½ cent and the bulb, which is made in large quantities at the glass factories, costs about 2 cents. It may appear from this that the present selling price of such lamps —18 cents for the ordinary size—is unnecessarily high; but when it is considered that there are some fifty operations in the process of manufacture, nearly all of which require special skill, and many of which involve refinements of manipulation which are nothing less than marvelous, this thought changes to one of wonder that the price can be made so low.—*The Illuminating Engineer.*

Officials Burdened With Minor Matters.—Officials in general are burdened with a senseless diversity of minor subjects under advisement. Long hours and hard work scarcely suffice to keep up with the mass of routine details. Careful thinking along broad general policies must be left to absorb time needed for rest and recreation away from the office. The secret of the success of the largest dry goods and manufacturing house in the country is the instant weeding out of every man as soon as he has reached the limit of his ability, whether it be as errand boy or partner. It follows that every boy who enters their employ understands that no dead timber is retained to block his opportunities for certain promotion as rapidly and as far as he can win it.—*Paul R. Brooks, before the New York Railroad Club.*

REPAIRS TO STEEL FREIGHT CARS.*

By J. F. MacEnulty.

As you are doubtless aware, the first steel freight cars in any large quantity were built in 1897, by the Schoen Pressed Steel Company. Previous to that time there were iron box cars on the New York Central in 1871; the Harvey Steel Car Company had built cars to order as early as 1891, and prior to 1888 some tubular frame cars were constructed by the Southern Iron Car Company. Prior to 1897, however, the steel car had many enemies and few good friends, due, doubtless, to a natural conservatism on the part of the railway men and to the obviously experimental stage of steel car development.

Some early designs of steel cars were gotten up in competition with wooden car weights which then existed, and the argument that a great ratio of paying load to dead weight was to be had sold a great many cars. As a consequence, many cars were designed that were really too light for the exceptionally heavy service. At this stage of development, however, the weight of the car up to a certain point is not considered; for instance, 50-ton cars for general service weighed, in 1902, 35,000 lbs.; to-day the same capacity cars weigh 45,000 lbs., or an increase in dead weight of 10,000 lbs. in four years. The questions now are: Will it stand the severe buffing shocks? Will it keep off the repair track? Railroads now realize that a car continually in service more than pays for the hauling of its dead weight by an increased number of loads. For roads where service is not so heavy a car with a greater ratio of paying load to dead weight can be used to advantage.

The first steel cars were built almost entirely of pressed shapes; then other manufacturers designed cars to be built entirely of structural shapes. To-day the builders of so-called "structural cars" use pressed shapes and structural shapes, and pressed shapes are used where in the mind of the designer they are most feasible. The days of light construction are over; we are increasing the weight of rails, of engines, etc, Where ten years ago an 80,000 lbs. capacity car was considered unusual, the 100,000 lbs. capacity car is now common, and the railroads look for a greater capacity. The time will come when many of us will see trains of cars, each unit carrying 150,000 lbs. or over. In fact, to-day this matter is being seriously considered by at least one leading road. True, there are many such cars now, but they are made for special use, and cannot be classed as a general service type.

From the records of nine representative car-building concerns in the year 1905 there were 224,817 cars ordered; of these 148,493 were steel and 76,324 of wood. With steel cars coming so rapidly to the front, the question of repairs is a very live issue. In repairing steel cars a road which has none in service usually resorts to the use of skilled labor or will return the cars to the builder; either method is costly, and is very apt to prejudice the management's decision when the question of steel versus wood construction is brought up. There is absolutely no need of any railroad, large or small, employing skilled labor or returning the cars to the manufacturer. Skilled labor is not used at shops where cars are built; then why use skilled labor to repair them? When a car is new, naturally the question of appearance and finish is one of the important points of inspection. When a car is out of service the question of utility is uppermost, and any repairs should be made in the cheapest manner consistent with good service. Why pay boilermakers' prices to have a perfectly finished rivet driven, when a laborer at half the pay will drive one in half the time that will perform its office satisfactorily? A little experience with the rough-and-ready car repairer versus slow skilled labor is usually convincing. Railways are now using the same repair gangs for both wood and steel cars, and the results are shown in the reports of car repairs published from time to time in the railway journals. If the car foreman lacks the ingenuity or confidence to make

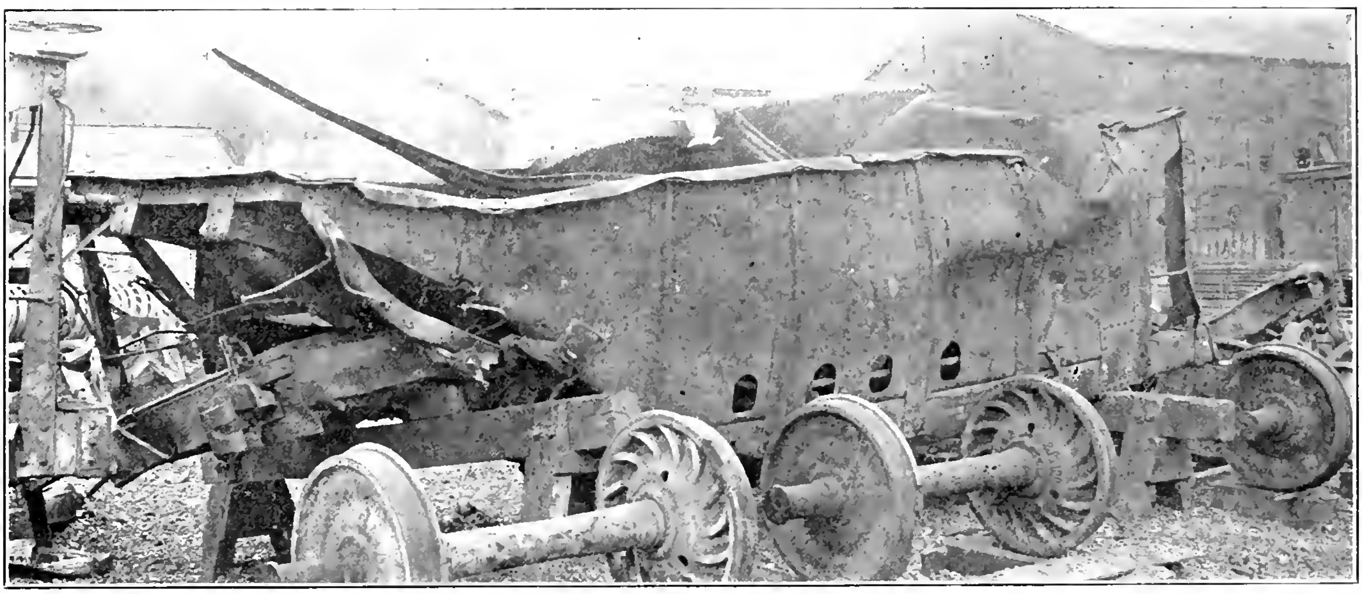
*From a paper presented before the October meeting of the New England Railroad Club.

the necessary repairs, send him to Altoona, Mt. Clare or Collinwood, where they are past masters in the art. Unless his natural prejudice has overcome his mental balance, the expense of his trip will be repaid many times.

In the early days of repairs to steel cars it was the custom when a sill was bent to dismember the car and take the piece out to straighten it. Now, an oil furnace or a charcoal fire is put under the car, and when the sill is heated sufficiently it is put back into shape by a pulling jack applied to suit conditions. When sills are broken a splice can be made by making a butt joint with plates on inside and outside, all securely riveted.

Steel cars received on repair tracks on account of wrecks very seldom have any of the frame or body lost, so it is simply a matter of cutting off the bent small parts, straightening them and riveting in place.

It is, however, advisable when purchasing new cars to order a small supply of the steel shapes that will most likely be needed for running repairs. This saves time and inconvenience, for no matter what arguments may be put forth about buying shapes, etc., in the open market, when the time comes for such purchase it will be found hard to get immediate delivery, and harder still to shape material for application



EXAMPLE OF BADLY WRECKED STEEL FREIGHT CAR.

to cars. On the average road there is not enough demand for repair parts to warrant the expense of putting up a special shop; this condition makes it necessary to look to the car builder for material, whether it be of structural or pressed shapes.

Pressed and structural members, or such as end and corner posts, stakes, flange angles and plates, can be cut off by hand and heated in a gas or oil fire, and straightened on a large flat surface plate or anvil with ordinary smith's tools. One gang of men at this forge can take care of this class of work for a large number of cars. Heating and bending will not injure the steel entering into the construction of cars, so that practically all the parts removed from a steel car can be utilized either in their original shape or as a patch on some other part.

It must be taken into consideration that shocks and treatment that would ordinarily destroy a wooden car merely make the steel car an object that draws the anathemas of the wrecking crew, and the solicitous consideration of the repair gang. Gone is the inevitable bonfire that was a simple method of clearing up the debris. The alternative now is either to bury the car or send it to the repair tracks; it won't burn. Heavier and more powerful cranes are necessary, but the right of way is more easily and quickly cleared. When a chain is put around a corner post or sill the whole car moves, not merely a section, as heretofore. The only record of steel cars wrecked, that could not be repaired, were a few near Pittsburgh that rolled over a 200-ft. embankment into a swollen river and were carried about two miles away from the railroad. It was impracticable to tow them back. Aside from a few similar instances, there is no record of a steel car being wrecked in such a manner that the cost of repair would render it advisable to scrap it.

The cost of steel car repairs is, on the whole, very small by comparison, when it is taken into consideration that comparative costs of repairs of the two types as given by railways are, as a rule, manifestly unfair. The maintenance reports given for publication are generally taken only for cars that have been repaired. When it is a wood car this means, on an average, slight repairs. But what of the wood cars destroyed? There are thousands of such every month. Should not the cost of renewals, less a scrap credit, be added to the wood car maintenance sheet to arrive at an equitable basis for comparison with the steel cars? This would throw a great balance on the steel car side of the controversy, and would bring forth the argument that many of the wood cars thus destroyed were old and of an obsolete type. While this is true, yet the old car has a money value; a car is a car on the records, and the failure of the old wood cars serves only to enhance the value of the up-to-date steel car that will not disintegrate.

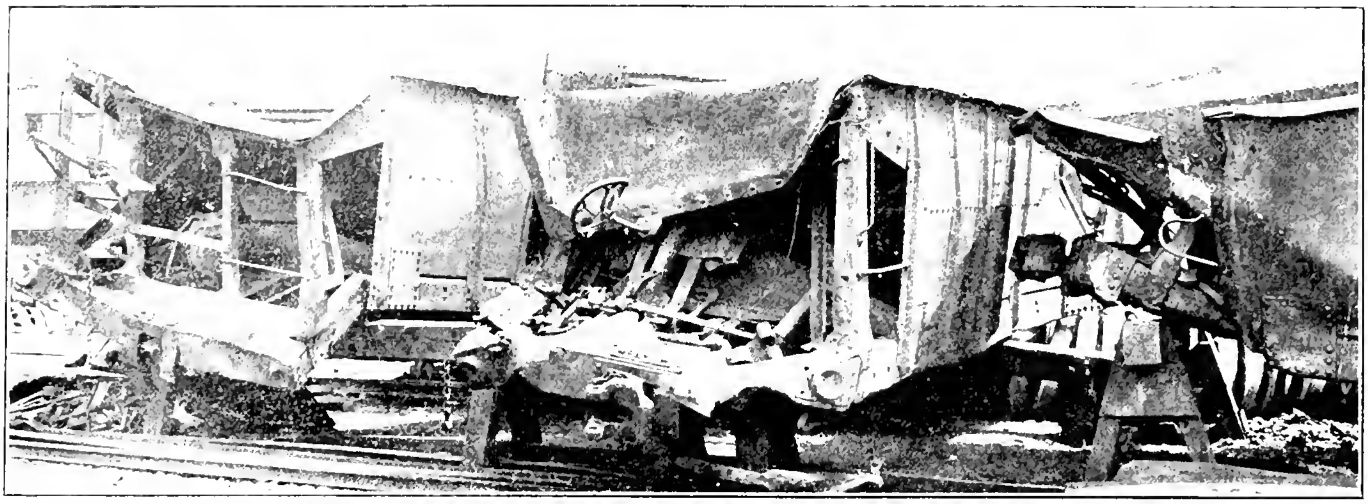
The average cost of repairing steel cars varies considerably with the type, and as a larger number of 100,000 lbs. capacity steel hoppers have been built than any other class, costs of their repair would be more interesting. Below is a record of average costs of certain kinds of repair to this type:

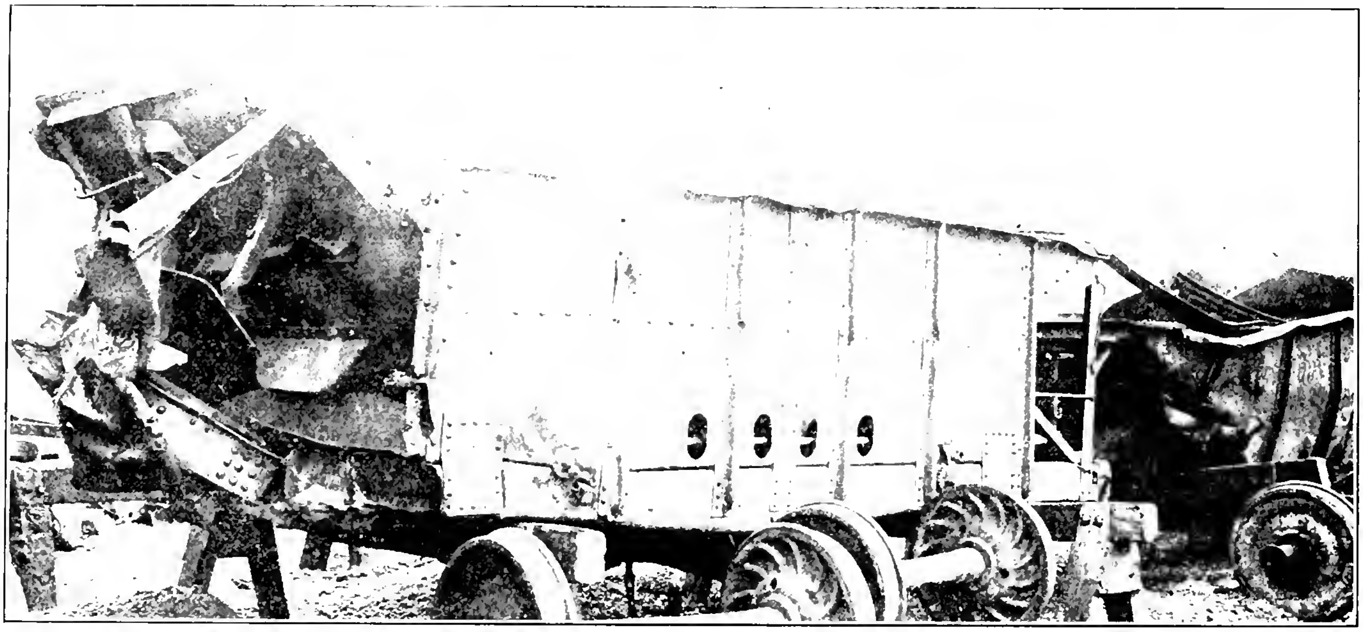
COST OF REPAIRING 100,000 LBS. CAPACITY STEEL HOPPERS.

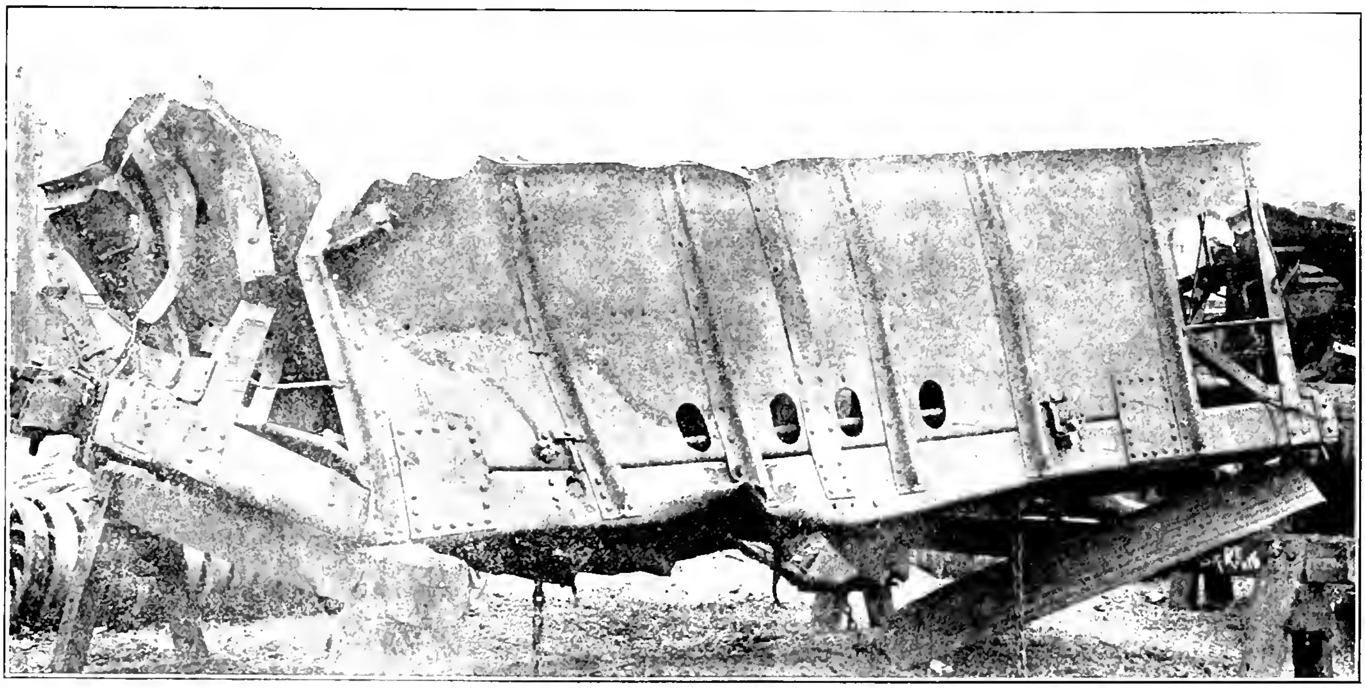
One end having side and end sills, draft sills and corner braces and brackets badly bent....................$36.50
Both ends damaged as above and body badly sprung.......... 85.75
To cut entire frame and body apart and re-rivet..............140.00
The above is the labor charge of cutting off the bent parts, straightening and re-riveting in place, the only new material used being rivets.
A steel car having been in a wreck that would totally destroy the body and frame of a wooden car can be repaired as good as new for....................$50.00
A steel hopper so badly wrecked that scrapping it was considered was repaired good as new for....................160.00

These figures are from systems using over 100,000 steel cars, some of them having been in service from seven to eight years. They estimate that the cost of car maintenance is reduced 35 per cent., and stock for repairs 50 per cent., by use of all-steel construction, taking an equal number of cars of both types as a basis.

As regards care of cars, while some roads do not consider it necessary to repaint their steel freight equipment, yet the old saw, "An ounce of prevention is worth a pound of cure,"







EXAMPLES OF BADLY WRECKED STEEL FREIGHT CARS.

might be applicable. Any metal surface exposed to the elements is none the worse for a little attention, and on any other structure it would be considered a necessity. At a prominent repair point, where 500 cars per month are repainted, the average cost for gondola or hopper cars is as follows:

Sand blasting	$0.45
Paint for body and lettering............................	6.00
Labor for body and lettering (according to locality)....	$1.00 to 2.00

The above costs for repair and painting do not include the trucks. The accompanying photographs illustrate what a steel car will stand. These cars, each containing fifty tons of ore, ran three miles down a 4 per cent. grade, and with the engine jumped over the end of a switchback, the cars and engine going by actual measurement 422 ft. before striking the ground; the point of contact was frozen ground, the drop being 53 ft. from track level. The engine and cars then rolled 516 ft. These seven cars originally cost about $1,200 each. The cost to repair was an average of $690 each, which was the manufacturer's cost, and included 10 per cent. profit and an operating and administration expense that on a railroad would be largely taken care of in other operations, and not charged entirely to cars, as is necessary for a car builder. A large part of the cost was in the trucks, owing to the peculiar nature of the wreck. Eliminating the trucks, the repairs to the bodies cost but $350 each. In repairs to trucks alone, it was necessary to replace 17,700 lbs. of steel, 56 journal boxes and lids, 51 brake shoes, 56 journal bearings and wedges, 28 groups of springs, 20 axles, 25 wheels, 1,200 lbs. of forgings and 3,900 lbs. of castings, or a total of 68,800 lbs. of material. A wood car under similar conditions would have been good only for firewood and a small scrap credit for truss rods, grab irons, etc. This wreck for a small number of cars represents about as severe a condition as could be met, and goes to prove the argument that a steel car is always good enough to be repaired.

LOCOMOTIVE BOILERS WITH COMBUSTION CHAMBERS.

Referring to the second paragraph of the editorial in your October issue on the Northern Pacific engines with the combustion chamber which states, "The combustion chamber was used in the original Wootten fireboxes and remained a part of that design until it was found to be of no particular advantage, and engines without it steamed as well and were less expensive to maintain."

These are not the facts in the case entirely. The majority of the anthracite roads, while they had a few engines equipped with the combustion chamber, had comparatively few. The Reading Railroad, however, had a very large number of engines with the combustion chamber. For some cause or other, which I do not know at the present time, it was decided about five years or more ago that whenever one of these engines received a new firebox, the combustion chamber was to be omitted, and a straight flue sheet put in instead, the reason doubtless being the trouble they were having with combustion chambers. We now have running on the road, due to this policy, engines with and without combustion chamber of absolutely the same design and dimensions throughout. There is no question whatever that engines with combustion chambers, although having a less amount of total heating surface, are better steamers, give much less trouble with flues, and are cheaper to maintain as regards boiler repairs. Moreover, it is very frequently necessary, due to a shortage for some local cause, of fine anthracite coal, to occasionally burn straight soft coal in these Wootten boxes with combustion chambers, and, while the grate surface is too large for the straight soft coal, and more steam is generated than can be used, still under these conditions, there is no question again but that the combustion chamber engine has very decided advantages over the straight flue sheet, and our experience in this matter would certainly indicate the use of a combustion chamber in a soft coal engine as a desirability.

The principal trouble with the combustion chamber engines has been largely due in the past to two causes; first, the very narrow water space surrounding combustion chamber, which, in many cases, on the older engines, is not over three inches, and secondly, the fact that the majority of water stations on the Reading Road have a water supply which contains a very high percentage of mud, and which mud was almost always found deposited first under the combustion chamber, filling the opening up entirely, and burning out, cracking and breaking the sheets. On the older engines, this trouble has practically been done away with by the application of a very large and easy opening blow-off cock directly underneath combustion chamber, and the putting in force of rules requiring two or three gauges of water to be blown out of engine through this blow-off cock daily, thus removing the mud from under the combustion chamber.

The advantages of the combustion chamber engine in steaming qualities, maintenance of fire box and flues over the straight flue sheet are so very decided that during the last two years all engines built have been equipped with this combustion chamber, and undoubtedly this policy will continue. Of course, in the newer design of engine, very much larger water space surrounding combustion chamber has been given, as well as the blow-off cock to remove the sediment which accumulates at that point.

From the above it will be noted that the combustion chamber is not abandoned, and that furthermore, the Northern Pacific are not the first to burn straight soft coal with combustion chamber, as this has been done many years ago, and very successfully, although, as before stated, such coal not being standard to the design of engines, furnished more steam than could be used.

Yours truly,

F. F. GAINES,
Reading, Pa. Mechanical Engineer.

ELECTRIC CAR TESTING PLANT.—The new electrical laboratory of the Worcester Polytechnic Institute, Worcester, Mass., now in process of construction, which will be one of the largest in the world, will have an interesting plant for the study of electric railroad traction. The equipment of this department will consist of a motor generator set, a four-motor electric car equipment, a complete set of multiple unit control apparatus and complete air-brake equipment. The motor generator set is composed of a 300-h.p. 2,200-volt 60-cycle synchronous motor, mounted on the same base with and directly connected to a 200-k.w. rotary converter, arranged to deliver either 600-volt direct current or 400-volt two-phase or single phase 25-cycle alternating current, as may be required. The car equipment consists of four motors of a combined capacity of 160 h.p., with controllers, trolleys, switches, resistances, cables, etc., all of the latest type of the General Electric Company, and will be used for the motive power of the institute's test car, which will be of the modern interurban type, as large as will safely pass over the New England electric lines. The car will be equipped with instruments and apparatus for making exhaustive tests of the lines over which it passes. The control apparatus will be mounted in working order in the laboratory and will be so arranged that it may be used as control for the test car. A Westinghouse electric pneumatic unit switch control system will also be installed, so that both systems may be studied and comparisons made under different operating systems. There will be a number of air-braking outfits of the several makes.—*Iron Age.*

FORMAL OPENING RAILROAD Y. M. C. A.—The Norfolk & Western Railway recently voted to expend $70,000 in buildings for Young Men's Christian Associations on their line, and in connection with the opening of one of these buildings—that at Portsmouth, Ohio—on Thursday, November 15, President L. E. Johnson, of the Company, made the following statement: "This association is an association not only of you men who realize its need, but the officials of the road are associated with it in building it and putting the money of the stockholders into it and for its support, all because we heartily believe in it, and we count it as one of the necessary items of expense in modern railroad equipment. There should exist among yourselves an effort to maintain the manhood of your association work. I congratulate you on the opening of this building, its secretaries, board of management and friends; and last, but not least, the men who shall be most directly benefited—the men of the Norfolk & Western Railway service, and wish you Godspeed in your undertaking in this association for the days to come."

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BETTERMENT WORK.

"Eliminating wastes" may be said to be the watchword of betterment work. Mr. Frederick W. Taylor, the recent president of the American Society of Mechanical Engineers, was one of the first to systematically and scientifically study this matter and to introduce methods to reduce the wastes to a minimum and bring the efficiency of an operation or of an entire plant to a high point.

Some few persons seem to have thoroughly grasped the spirit of Mr. Taylor's work and have applied it with splendid results. Needless to say, the carrying on of such work requires an exceptional man and one of very broad caliber. One superintendent of motive power imbued with this spirit accomplished splendid results, such wonderful results in fact, that his work attracted the attention of several prominent manufacturing concerns, and he found it much to his advantage to leave railroad service.

There can be no question but what on many railroads there are very great possibilities for increasing the efficiency of the motive power department and operating it more economically, but this can never be completely accomplished until those in charge wake up and place the motive power department on the high plane which its importance deserves. Then, instead of allowing manufacturing concerns to take our best men, conditions will be reversed and the railroads will see to it that the men who are fitted to accomplish such wonderful results will not be allowed to drift away into other work.

* * * * * * *

It must not be understood from the above that there are not many very high grade men in the motive power department and that they are not doing splendid work, but in many instances the results of their efforts would be multiplied many times over if they had the power and authority that they should have. While the motive power departments have been steadily widening out and increasing in importance, it was not until recently that special efforts were made along betterment lines, and indeed these efforts at the present time are confined to a few of the roads and, generally speaking, are directed along widely different lines. One road, for instance, realizes the importance of perfecting the organization of the motive power department. A careful study is made of the qualifications of the different men. Where advisable, salaries are increased to keep good men and to encourage them in their efforts. Measures are taken to get the leaders together and have them work as a team or unit. At the same time shop equipment and conditions are improved and an attempt is made to raise the standard of the workmen. All this, of course, has accomplished splendid results. On another road little has been done to improve the supervision, but a system of handling the men has been installed to, as far as possible, secure their co-operation in increasing the efficiency and capacity of the repair plants. On still another road a competent man, and one of long experience, has been appointed to follow up certain features of the work, to make a careful study of them and to at the same time increase the efficiency and reduce the expense for that particular work or department. On another system we find that a committee has been appointed whose duty it is to carefully investigate all the shops and repair plants on the system and to present recommendations for improving their efficiency.

* * * * * * *

The road, however, that has taken the most radical measures is the Santa Fe. This work was described at length in our December issue, in fact we considered it of such importance that almost the entire paper was devoted to that one subject. The methods of Mr. Harrington Emerson, who has had charge of the betterment work on that road, differ quite materially in detail from those of Mr. Taylor, but are actuated by the same spirit or general principles. In a nutshell, the results accomplished on the Santa Fe are due to the increased supervision and to the fact that the co-operation of the men was secured in eliminating wastes and improving the efficiency.

* * * * * * *

One feature in connection with the betterment work on the Santa Fe should be clearly understood. While this work was started by a separate organization, known as the betterment department, yet it has been the policy, as far as possible, to work through the mechanical department organization and to make the duties of the betterment department largely advisory. For instance, for a considerable time the betterment work at the Topeka shops has been handled entirely by the shop organization. After the betterment department had gotten the work well started it was placed in the hands of Mr. John Purcell, the shop superintendent, and with the advice of the betterment department he completed its introduction. Gradually the entire work of the betterment department is thus being absorbed by the mechanical department organization.

The appointment of Mr. H. W. Jacobs to the position of assistant superintendent of motive power of the Santa Fe, as announced on another page of this issue, has a peculiar significance. Mr. Jacobs has been connected with the betterment work from its very start and has had charge of betterments to the shop equipments and tools for the entire system, and has had entire charge of the betterment work on the Coast Lines since it was first introduced there. As it is only a question of a short time when Mr. Emerson will find it necessary to give up his work on the Santa Fe, the betterment work will undoubtedly be entirely absorbed in the mechanical department organization and will be carried on under Mr Jacobs as assistant superintendent of motive power.

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The bonus system introduced on the Santa Fe must not be confused with other bonus systems: for instance, under other systems no bonus is paid unless the standard time is reached. If the standard time for a piece of work is four hours and the man sees that it will take a little more than four hours to do the work, and that he will be unable to earn any bonus, there is no incentive for him to hurry the work through, as his rate of pay will be just the same if he takes five or six hours to do it. With Mr. Emerson's system the job would begin to pay a small bonus for time and a half, or six hours, and this would gradually be increased, as the time was reduced, until at four hours the bonus would be 20 per cent. If the job is done in less than four hours, under Mr. Emerson's system the worker gets the entire benefit of his efforts, while with other systems the profit due to the gain in the man's time is divided between the man and the company.

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An important feature in connection with the bonus system on the Santa Fe is the abolishing of overtime. In the repair shops the bonus schedules lapse when overtime is paid, thus tending to discourage the custom of working overtime. If a man works beyond a certain point his efficiency becomes impaired and the company is the loser.

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The question may arise as to the reduction in the force because of the increased output due to the introduction of the bonus system. In all large shops men are continually leaving the service and being replaced by new ones. When introducing the bonus system on the Santa Fe it was found unnecessary to make any special reduction in the force, but as men dropped out they were not replaced.

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The graphical records used in connection with the betterment work on the Santa Fe are an important feature. Such records can be maintained at a comparatively small cost. They enable the officers to quickly and accurately comprehend the condition of affairs, giving them an accurate and broad view of the situation and locating the weak points. Graphical records have been used very extensively upon the Chicago Great Western and the Northern Pacific Railways. The system in use in the mechanical department of the Northern Pacific Railway was described at length in an interesting article by Mr. L. A. Larsen in our December, 1905, issue, page 451. Mr. Emerson's idea of 12-month averages, which more clearly show the actual tendencies and eliminate differences due to seasons, etc., is, however, a new and valuable one.

During the past three years an interesting and valuable series of experiments has been under way at Purdue University for the purpose of accurately determining the relative economy of various steam pressures on locomotives. These have now been completed and a full report made to the Carnegie Institution of Washington, D. C., which instigated and paid the expenses of the experiments. An abstract of this report, giving its general features and results, was read by Dr. W. F. M. Goss at the November meeting of the Western Railway Club, and is given in full in this issue. It forms a valuable addition to the literature on steam locomotives, and positively settles some points about which there has been considerable conjecture. It shows, for instance, that while there is an increased economy with increased pressures up to 240 pounds per square inch, the amount of saving per increment of pressure very rapidly decreases as the pressure is increased above 180 pounds. This point is so decided as to lead to the conclusion that as far as economy is concerned it is not advisable to use pressures greater than 180 pounds on single expansion locomotives, and as high as that only when the boiler can be well maintained. The slight saving possible from higher pressures will no doubt be more than counteracted in practical service, by the loss from the many insignificant leaks generally accompanying it. Also, aside from the loss by direct leakage, the loss in evaporative efficiency of the boiler and the trouble with check valves and injectors by the much more rapid deposit of hard scale is also to be considered as an offset to the slightly increased economy.

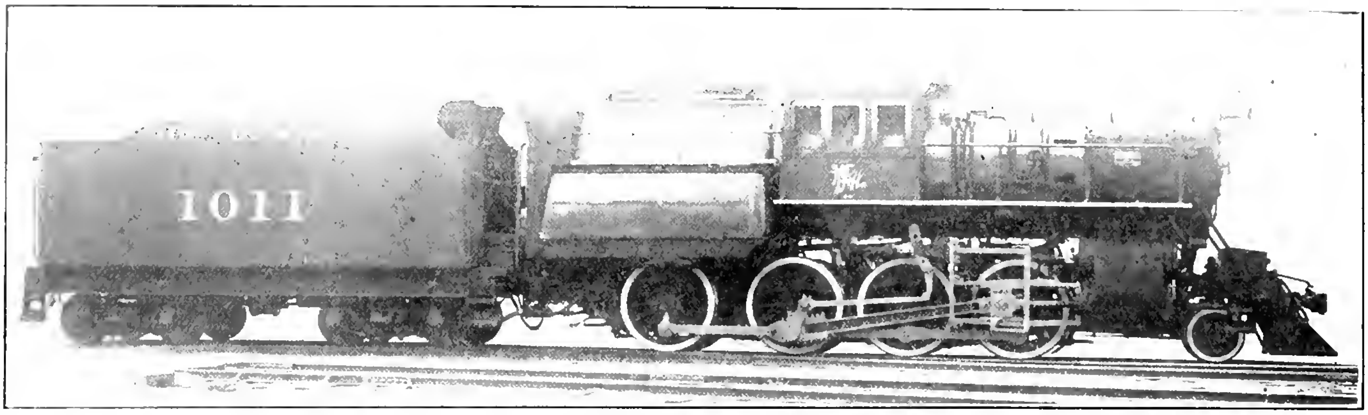
Dr. Goss made it clear, both in this paper and in his topical discussion at the last Master Mechanics' convention, that this question is being considered from the standpoint of design, and that the results do not necessarily indicate that it is advisable to reduce the pressures in boilers now carrying 200 pounds or more, even if the cylinders are enlarged to give equal power. The idea is consistently carried throughout the report that the comparisons are between boilers of equal weight and not equal size or heating surface.

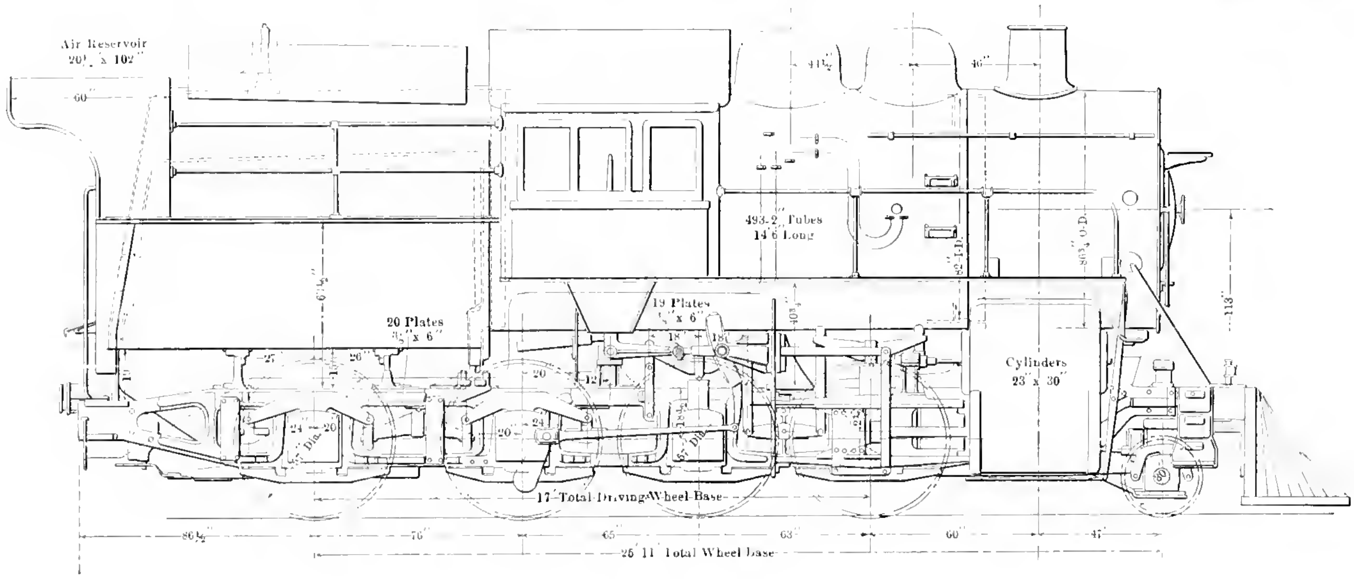
In an address delivered at the recent dedication of the new Engineering Building of the University of Pennsylvania, Mr. Frederick W. Taylor discusses the causes and possible remedies for one defect which, he states, practically all young college graduates seem to have in common. That is, their dissatisfaction and comparative uselessness for a period of from six months to two years immediately following graduation. An exception, however, is made of those men who through necessity or otherwise have, either before or during their college course, come into close contact and direct competition with men working for a living. That this condition has attracted serious attention was illustrated by an example cited wherein a certain company in filling several attractive positions, specified that technical graduates should be given a preference, but that none should be employed who had not been graduated for at least two years.

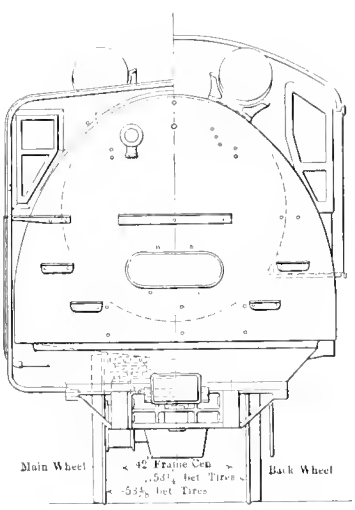
If such an idea becomes general, there is a hard time ahead for the young technical graduate, but we do not believe that the facts of the case warrant any such general application, and that an examination of the records of the men graduated from our technical schools in 1904 will show that any large proportion of them have been even comparatively useless to their employers. There are, no doubt, individual cases, and in certain particular localities possibly a fair proportion of the men where this condition will be found to be true, but it is a matter for individual consideration, and the whole class should not be condemned by the failure of one or two. This is a matter of men not of car wheels or air hose.

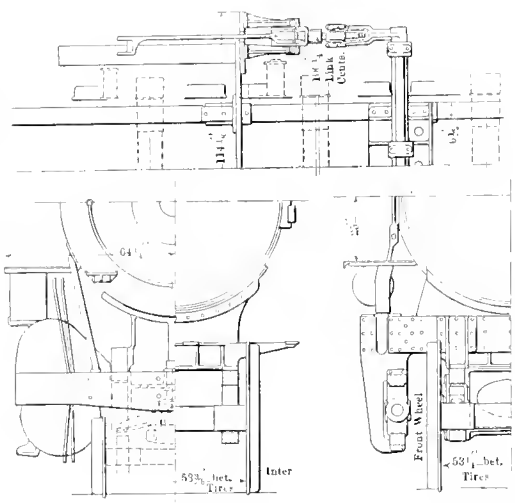
The address points out the fact that the sheltered existence, and comparatively lax discipline of the colleges and universities are such as to make the following contact with real life considerable of a shock and probable disappointment to the ordinary young graduate and makes several suggestions for improvement in this respect. Possibly the most important of these is the suggestion that the university make it obligatory for the student to spend six months or more, preferably at the end of the Freshman year, in some commercial, engineering or manufacturing establishment—there to work as an employe at whatever job is given him. The idea of this is to give the student close contact on an equal plane with practical workmen, so that he may be aided in developing an earnestness of purpose which will be of benefit not only after graduation, but in the remainder of his college course as well.

Some such scheme would, no doubt, be of much practical value to the student, provided it could be arranged so as not to curtail or further crowd the present usual course of instruction.









HEAVY CONSOLIDATION FREIGHT LOCOMOTIVE WITH WALSCHAERT VALVE GEAR.

DELAWARE & HUDSON COMPANY.

The American Locomotive Company has recently built, at its Schenectady works, six consolidation locomotives for the Delaware & Hudson Company, which are now in slow freight pushing service on the Honesdale branch, between Carbondale and Racket Brook, Pa. These locomotives weigh 246,500 lbs., of which 217,500 is on drivers, and are, with one exception, the largest and most powerful engines of this class of any on our record. The locomotive built in 1900 for the Pittsburgh, Bessemer & Lake Erie Railroad, which weighed 250,300 lbs. total, exceeds them slightly in weight and, by reason of its larger cylinders, higher steam pressure and smaller wheels, gives a much larger tractive effort. The accompanying table of four large consolidation locomotives will permit comparisons to be made between these engines and their nearest competitors. It will be seen that they have the same diameter of cylinders as are used on the heavy freight locomotives on the Lake Shore & Michigan Southern Railway, which were illustrated in our July issue, but, by reason of the smaller wheels and higher steam pressure, the tractive effort is considerably larger. The Lehigh Valley locomotive, also included in the table, was built in 1898 by the Baldwin Locomotive Works and has Vauclain compound cylinders. This was a single locomotive, built for pushing service, and at the time of its construction was next to the heaviest locomotive in the world.

The Delaware & Hudson engines were built for burning fine anthracite coal and have a grate area of practically 100 sq. ft. This is served by a single fire door 36 ins. wide and 12½ ins. high. The O'Connor patent fire door flange, which gives the inner firebox sheets a very large radius at the fire door opening, has been used. The barrel of the boiler is made up of two cylindrical sections, the forward and smaller one measuring 83¾ ins. outside diameter, and the other 85⅝ ins. The tubes, of which there are 493, are 2 ins. in diameter and 14 ft. 6 ins. long, giving a heating surface of 3,716 sq. ft., are set 2¾ ins. between centers.

The frames are cast steel of the I section design, which has been very successful on this road. The use of the Walschaert valve gear has permitted the frames to be well braced and stiffened at several points, particularly just ahead of the main drivers, where a very heavy combination cross tie and reverse shaft bearing has been placed. Unusually large and long pedesial binders, which are fastened by three bolts, passing through the frame on either end, have been used. The design of the Walschaert vaive gear used in this case is very similar to that employed on other freight locomotives recently built by this company. The support for the valve stem is carried on the upper guide bar and the connection to the combination lever is below the radius bar connection. The link is carried by a bracket extending back from the guide yoke. The location of the reverse lever has allowed the direct connecting of the reverse shaft arm to the radius bar of the valve gear through a slip joint. The general dimensions, weights and ratios are as follows:

Road	P. B. & L.E.	D. & H.	L.S. & M.S.	L. V.
Total weight, lbs.	250,300	246,500	232,500	228,082
Weight on drivers, lbs.	225,200	217,500	207,000	205,232
Tractive effort, lbs.	63,800	49,690	45,677	17,700
Size cylinders, ins.	24x32	23x30	23x32	18&30x30
Diam. of drivers, ins.	54	57	63	55½
Steam pressure, lbs.	220	210	200	200
Diam. of boiler, ins.	84	83¾	81⅝	80
Total heating surface, sq. ft.	3,805	4,015.5	3,705.23	4,145
Tube heating surface, sq. ft.	3,564	3,716	3,492.18	3,952
Grate area, sq. ft.	36.8	99.75	56.5	90
Fuel	Bit. coal	Anth. coal.	Bit. coal	Anth. coal
Total weight ÷ total heat. surface	65.8	60.8	62.8	55
Weight on driv. ÷ total heat. sur.	59	53.9	56	49.5
Trac. effort × diam. driv. ÷ t't'l H.S.	905	700	775	640
Weight on drivers ÷ total weight, %.	90	88.5	88.5	90
Total heat. sur. ÷ vol. cylinders	228	280	240	305
Reference in AMERICAN ENGINEER	1906 p. 214	This issue	1906 p. 262	1898 p. 395

SIMPLE CONSOLIDATION LOCOMOTIVE.

DELAWARE & HUDSON COMPANY.

GENERAL DATA.

Gauge ... 4 ft. 8½ ins.
Service ... Freight
Fuel ... Hard coal
Tractive effort ... 49,690 lbs.
Weight in working order ... 246,500 lbs.
Weight on drivers ... 217,500 lbs.
Weight on leading truck ... 29,000 lbs.
Weight of engine and tender in working order ... 398,900 lbs.
Wheel base, driving ... 17 ft.
Wheel base, total ... 25 ft. 11 ins.
Wheel base, engine and tender ... 57 ft. 7½ ins.

RATIOS.

Weight on drivers ÷ tractive effort ... 4.37
Total weight ÷ tractive effort ... 4.97
Tractive effort × diam. drivers ÷ heating surface ... 700
Total heating surface ÷ grate area ... 40.5
Firebox heating surface ÷ total heating surface, per cent ... 8.12
Weight on drivers ÷ total heating surface ... 53.9
Total weight ÷ total heating surface ... 60.8
Volume both cylinders ... 14.4 cu. ft.
Total heating surface ÷ vol. cylinders ... 280
Grate area ÷ vol. cylinders ... 6.92

CYLINDERS.

Kind ... Simple
Diameter and stroke ... 23 x 30

VALVES.

Kind ... Piston
Greatest travel ... 5½ ins.
Outside lap ... 1 in.
Inside clearance ... 0 in.
Lead in full gear ... 3/16 in.

WHEELS.

Driving, diameter over tires ... 57 ins.
Driving, thickness of tires ... 3½ ins.
Driving journals, main, diameter and length ... 10 x 12 ins.
Driving journals, others, diameter and length ... 10 x 12 ins.
Engine truck wheels, diameter ... 30 ins.
Engine truck, journals ... 6½ x 12 ins.

BOILER.

Style ... Straight
Working pressure ... 210 lbs.
Outside diameter of first ring ... 83¾ ins.
Firebox, length and width ... 126¼ x 114 ins.
Firebox plates, thickness ... 3/8 and 9/16 ins.
Firebox, water space ... 4 ins.
Tubes, number and outside diameter ... 193, 2 ins.
Tubes, length ... 11 ft. 6 ins.
Heating surface, tubes ... 3,716 sq. ft.
Heating surface, firebox ... 329.5 sq. ft.
Heating surface, total ... 4,015.5 sq. ft.
Grate area ... 99.75 sq. ft.
Smokestack, diameter ... 20 ins.
Smokestack, height above rail ... 15 ft. 2 ins.
Center of boiler above rail ... 113 ins.

TENDER.

Tank ... Water bottom
Frame ... 15 in. channel
Wheels, diameter ... 33 ins.
Journals, diameter and length ... 5½ x 10 ins.
Water capacity ... 7,800 gals.
Coal Capacity ... 14 tons

ELECTRICAL EQUIPMENT OF THE ERIE RAILROAD SHOPS AT HORNELL (HORNELLSVILLE), N. Y.

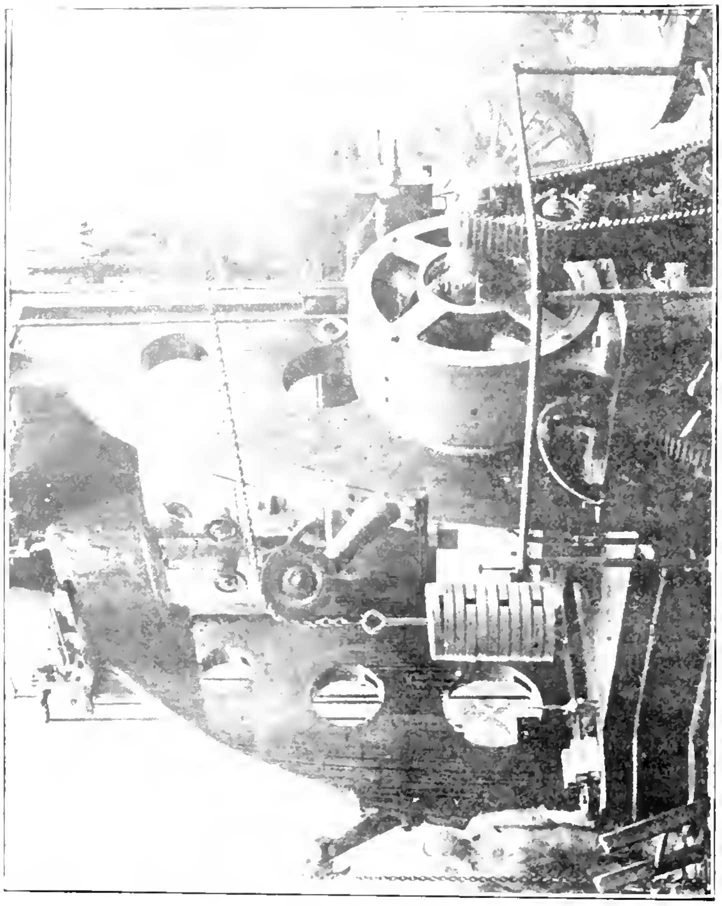
When the present management took charge of the Erie Railroad it adopted broad and comprehensive plans for the development of the entire property, which are rapidly making it one of the most modern and efficient railway systems in the country. These plans embraced extensive alterations and additions to the shops of the system in order to improve their efficiency and capacity.

New shop buildings and round houses have been constructed, old machines replaced by new, an efficient shop organization effected, and the entire mechanical department brought up to a high standard of efficiency. This work, under the direction of Mr. E. A. Williams, general mechanical superintendent, and Mr. G. W. Wilden, mechanical superintendent, has been carried on at many different points on the system, but the most extensive single installation of modern shop equipment is at the Hornell shops, located at Hornell, N. Y. At this point new buildings have been erected, additions made to old buildings, a new power house erected, and a large number of new machine tools, with a complete system of electric drive, installed. This installation is an interesting and instructive illustration of the latest engineering practice for a railway shop where the largest proportion of power is required at short distances from the power house, and a large proportion of variable speed and crane load is required.

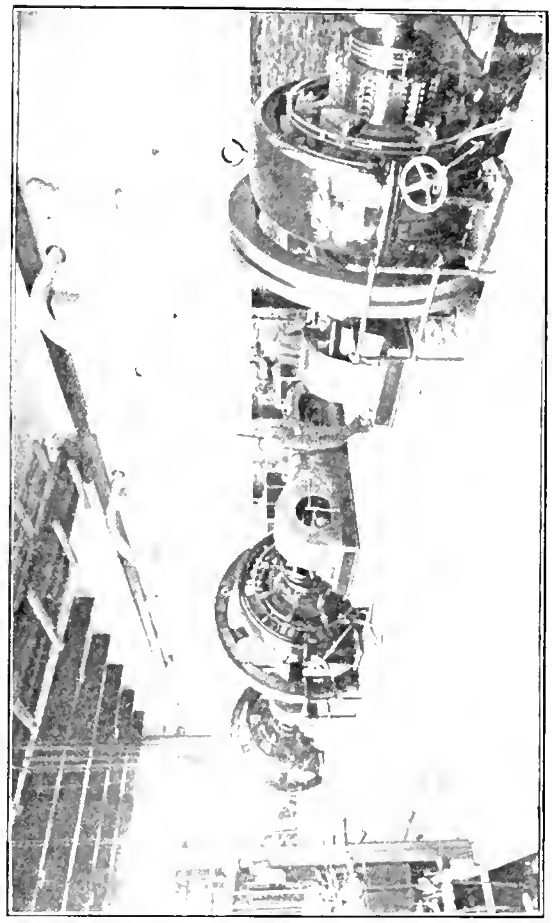
The operation of machine tools by electric motors is especially adapted to railroad shop work. The large work handled necessitates extensive buildings, and the use of great lengths of shafting and belting if power is transmitted mechanically from a central source. Rush repair jobs are frequent, and require a great deal of overtime and Sunday work, when power requirements are small, as but sufficient machinery is operated to complete the particular work at hand. Mechanical transmission of power under such conditions is wasteful in the extreme, owing to the surplus power required to overcome the friction of shafting and belting throughout the shops. Where the electric drive is used—either individual or group—a flexibility is obtained that cannot be secured by any other means, as it permits the use of a few machines independently, requiring a minimum amount of power.

There are many other considerations in connection with power transmission, one of the most prominent being the layout of the plant, which is especially important in a railroad shop, as it is generally made up of a number of separate buildings aside from the main machine and erecting shop, which are necessarily scattered, widely distributing the power requirements, and necessitating the use of a number of prime movers. Where engines are used, steam is supplied either from a central boiler plant or by individual boilers forming a combination unit with the engine. The former arrangement is poor, from an economical standpoint, owing to the low efficiency resulting from the excessive condensation which takes place in long lengths of steam pipe. Either method involves the expense of skilled attendants, which amounts to a considerable sum annually. Electric motors, on the other hand, require a small amount of attention, provide power that is perfectly reliable, and reduce the time of starting and stopping and changing speed to a minimum. The electric motor for operating cranes, transfer and turntables is superior to other motive powers, due to its ease of control, efficiency and reliability.

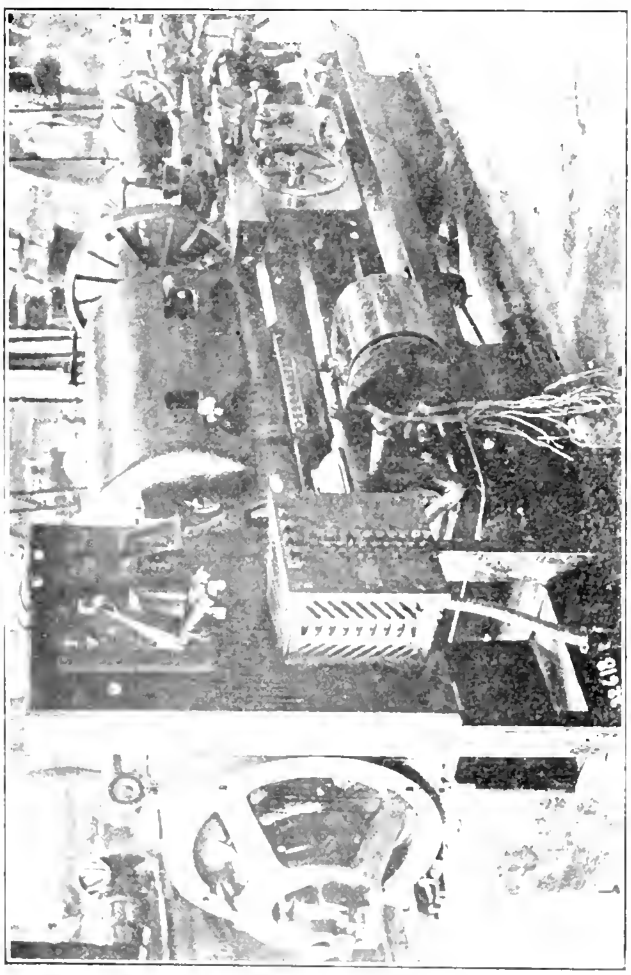
Before making a final decision as to the type of electrical apparatus to be installed a careful comparison was made of the alternating current and direct current types of apparatus. This analysis included not only the motors themselves, but also the various accessories, such as wiring, controllers, etc. Due consideration was also given to an installation involving the use of both alternating and direct current motors, but



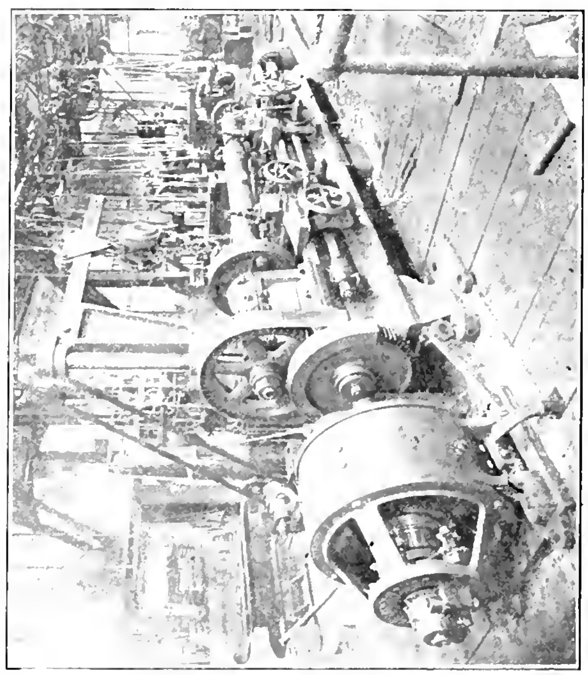
NILES 90-IN. BORING MILL—MOTOR-DRIVEN



INTERIOR OF ENGINE ROOM, POWER HOUSE

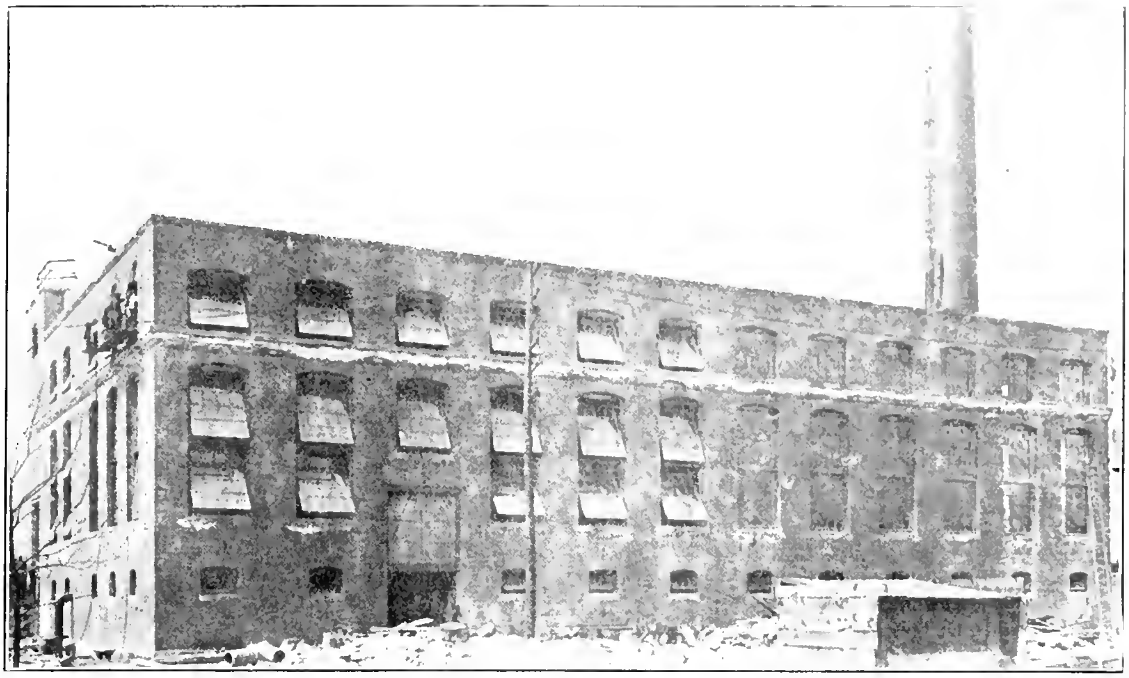


MOTOR-DRIVEN CRANK PIN LATHE.



NILES LATHE—MOTOR-DRIVEN

while it appeared probable that at some time in the future an equipment of this nature would be necessary, it was decided that present conditions did not justify the installation of both types of motors. Under the conditions existing at Hornell it is apparent that all of the motors are located well within the limits of 220 volts distribution, and in additon that there is at this time no woodworking shop in existence; therefore it was resolved to make the installation consist entirely of direct current apparatus, with the exception of a small generator set, which is used to supply the current necessary for the present yard and depot lights. This installation is an



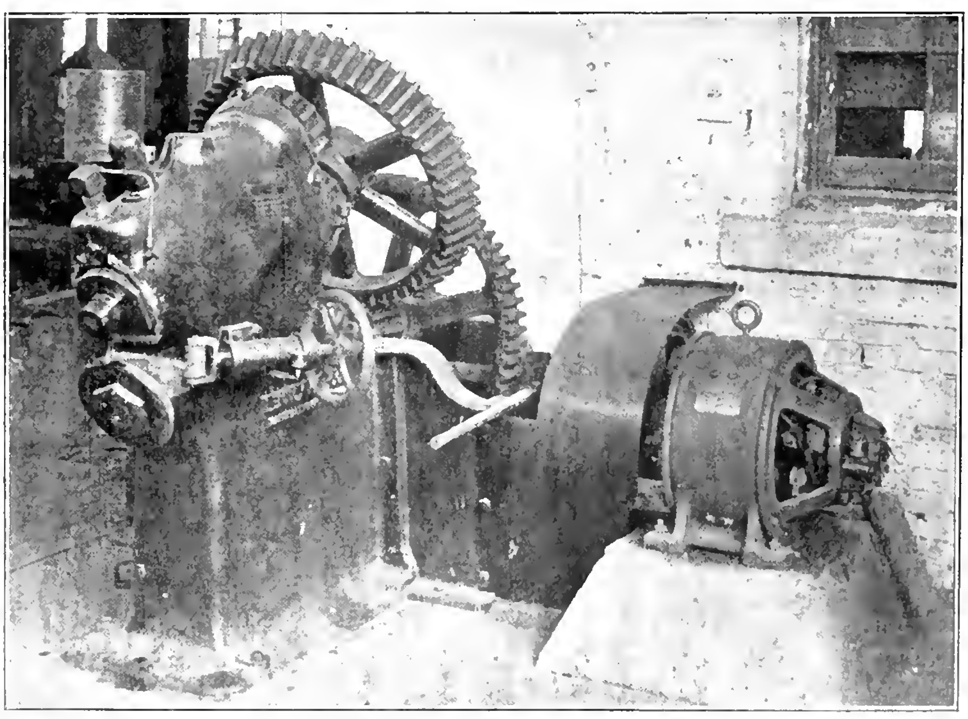
POWER HOUSE, HORNELL SHOPS—ERIE RAILROAD.

excellent illustration of the principle that each railroad shop must be considered as a separate and independent problem, and it is impossible to lay down any hard and fast rules which can be taken as a guide, but that each particular case must be thoroughly investigated, and a final decision reached in conformity with the conditions existing at that point.

Enlargement of the power house at some future time has been provided for. The type of apparatus to be placed in the engine room will be determined upon at the time of making the addition, as the present system can readily be expanded in either of two ways. Additional power can be obtained by the installation of the necessary capacity, either in an alternating current generator, which would supply the lines direct, the present motor generator set acting as a tie between the present units and the future one, or a direct current generator, with the necessary transforming apparatus for alternating current, can be installed if it is found advisable.

The power house is a large brick structure of fire-proof construction, with concrete roof and flooring. The building is large enough to provide for future extensions, foundations already being in place for doubling the boiler capacity, so that it is only necessary to erect the additional units. The boiler plant consists of four Babcock & Wilcox units of 400 h.p., operating at 150 pounds pressure, and equipped with chain grates. All live steam mains are provided with the Holley drip system. The coal handling and stoking is especially interesting, as, from the time the coal is dumped from the cars until it is fed into the furnace, it is conveyed automatically. The coal passes from the car into a chute, which empties into a crusher, and is then conveyed by an endless belt to the top of the power house, where it passes through another chute to the second conveyor that distributes it in the bunkers over the boiler room. From there the coal passes through chutes to hoppers in front of the furnaces, where it is fed onto the grates. The amount of coal admitted into the hoppers is controlled in the boiler room by means of levers. The conveyors, which were manufactured by the Exeter Machine Company, have a capacity of sixty tons per hour, and are operated by a 10-h.p. and a 13½-h.p. Westinghouse, type S, motor. The coal crusher is operated by a 20 h. p., type S. motor.

The generating equipment consists of three Ball & Wood cross-compound, high-speed condensing engines, two of 500-h.p., each direct connected to a Westinghouse 300 kw., direct current, 250-volt, 3-wire generator running at 150 r.p.m., and one of 400 h.p. direct connected to a similar generator of 200 kw. capacity, operating at 200 r.p.m. The engines run condensing except in cold weather, when the exhaust steam is utilized in heating the shops. Water for condensing purposes is stored in a large well, which derives its supply from a



LENOX BEVEL SHEAR, MOTOR-DRIVEN.

small river near the power house.

Besides the generating equipment and pumps there are two Ingersoll-Sergeant compound air compressors that furnish compressed air to the pneumatic hammers in the shops.

A motor-generator set supplies current for the yard and depot lights. It consists of a 115-h.p. Westinghouse, type S, motor direct connected to a 75 kw., Westinghouse 2-phase, 60-cycle, 1040 volt revolving field alternator operated at 900 r.p.m. A standard Westinghouse switchboard is provided with 3 motor-generator panels, 2 alternating-current and 1 direct-current generator panels, 6 feeder panels and 1 load panel, 2 blank panels providing for future extensions. The six feeder panels control six circuits, as follows:

No. 1. New erecting shop, 120-ton crane and transfer table.
No. 2. Carpenter shop, blacksmith shop, new boiler shop and tank shop motors.
No. 3. Roundhouse turntable, machine shop, coal pocket and ash-pit motors.
No. 4. All line-shaft motors.
No. 5. Individual drive motors.
No. 6. Motors in power house for coal-conveying apparatus.

Each feeder panel is also provided with switches for controlling the various lighting circuits.

Current is transmitted by cables through a large tunnel to the new erecting shop, and thence through underground conduits to the various buildings. The Westinghouse three-wire system of distribution is used for lighting and power, with an electro-motive force of 250 volts between the outside wires and 125 volts between each outside wire and the neutral. There is a decided advantage in the flexibility of the voltage, as incandescent and Cooper-Hewitt lamps are operated on the 125-volt sides of the system and constant-speed, 250-volt motors are connected to the main or outside wires, while the variable speed motors utilize shunt field control.

The old erecting shop utilizes both group and individual drive, the group driven machines being divided into five sections, and operated by five type S constant speed motors, two of 30 h. p. capacity and three of 50 h. p. capacity. The machines in the fitting shop, which occupies one wing of the erecting shop, are also group driven by a Westinghouse 30-h.p. constant speed, type S, motor. A complete list of the machine tools operated in each section is given below:

SECTION 1.—50-H.P., CONSTANT SPEED, TYPE S MOTOR.

Wheel press, 100 tons capacity.	Vertical boring mill, 53 in.
Wheel press, 300 tons capacity.	Vertical boring mill, 42 in.
Car wheel borer.	Vertical boring mill, 37 in.
Double car axle lathe.	Upright drill, 36 in.
Single car axle lathe.	Upright drill, 28 in.
4-Spindle drill.	Pillar shaper, 24 in.
Horizontal boring machine.	Planer, 32 x 32 in. x 8 ft.
Engine lathe, 24 in.	Turret lathe, 1½ x 24 in.
Driving wheel lathe, 80 in.	Quartering machine, 90 in.
Two 16-in. engine lathes.	Duplex emery grinder.
Engine lathe, 18 in.	7-Spindle nut tapper.
Engine lathe, 15 in.	Upright drill, 40 in.
Slotter, 10 in.	Small flange punch.
No. 4 plain milling machine.	

SECTION 2.—30-H.P., CONSTANT SPEED, TYPE S MOTOR.

Planer, 60 x 60 in. x 19 ft.	Slab milling machine.
Radial drill, 5 ft.	Drilling, facing and tapping machine, 40 in.
Radial drill, 4 ft.	Duplex emery grinder.
Slotter, 18 in.	Triple head slotter.
Two 2-in. double bolt cutters.	Upright drill, 40 in.
Staybolt cutter, 1½ in.	Two 16-in. engine lathes.
Slotter, 12 in.	One 1½-in. bolt pointer.
2-Spindle centering machine.	

SECTION 3.—50-H.P., CONSTANT SPEED, TYPE S MOTOR.

Planer, 42 x 42 in. x 18 ft.	Horizontal boring machine.
Ring turret lathe.	Engine lathe, 14 in.
Upright drill, 48 in.	Two 16-in. engine lathes.
Engine lathe, 42 in.	Vertical boring machine, 42 in.
Engine lathe, 30 in.	Upright drill, 40 in.
Engine lathe, 24 in.	Planer, 32 x 32 in. x 8 ft.
Crank planer, 20 x 20 x 24 in.	Radial drill, 5 ft.
Turret lathe, 2 x 26 in.	Double-head traverse shaper.
Engine lathe, 36 in.	No. 4 plain milling machine.
Engine lathe, 36 in.	Engine lathe, 26 in.
Horizontal boring machine.	Engine lathe, 30 in.

SECTION 4.—50-H.P., CONSTANT SPEED, TYPE S MOTOR.

Engine lathe, 16 in.	Cylinder boring machine.
Engine lathe, 24 in.	No. 17 Landis grinding machine.
Pillar shaper, 24 in.	Vertical boring machine, 42 in.
Friction drill.	Upright drill, 36 in.
Planer, 36 x 36 in. x 10 ft.	Upright drill, 28 in.
Planer, 36 x 36 in. x 8 ft.	Upright drill, 48 in.
Planer, 32 x 32 in. x 8 ft.	Engine lathe, 36 in.
Engine lathe, 20 in.	Engine lathe, 30 in.
Engine lathe, 18 in.	2-Fox turret lathes.
Engine lathe, 16 in.	Vertical boring machine, 86 in.
Engine lathe, 24 in.	Duplex emery grinder.

SECTION 5.—30-H.P., CONSTANT SPEED, TYPE S MOTOR.

Turret lathe, 2x26 in.	Key slot milling machine.
American brass lathe, 20 in.	Engine lathe, 30 in. piston rods.
Engine lathe, 24 in.	Planer, 36 x 36 in. x 10 ft.
Slotter, 18 in.	

FITTING SHOP—30-H.P., CONSTANT SPEED, TYPE S MOTOR.

Upright drill, 28 in.	Upright drill, 40 in.
Arbor press, 30-ton.	Arbor press, 15-ton.
Planer, 36 x 36 in. x 8 ft.	2-Spindle centering machine.
Vertical boring machine, 37 in.	Buffing wheel.
Three 18-in. engine lathes.	Small emery grinder.
Engine lathe, 16 in.	Surface grinder.
Engine lathe, 30 in.	Guide grinder.
Bench speed lathe, 11 in.	Polishing tape and wheel.
Pillar shaper, 24 in.	Swing grinder.
Crank planer, 20x20x24 in.	Friction drill.

In addition to the group-driven machines in the erecting shop there are a number of individually driven machines operated by both constant and variable speed Westinghouse Type S motors, as follows:

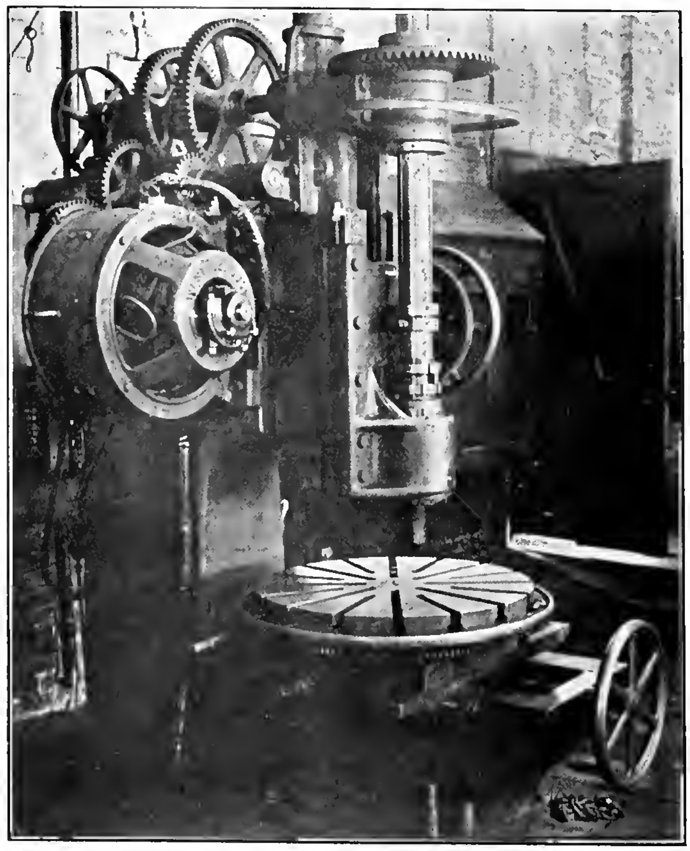
CONSTANT SPEED MOTOR-DRIVEN MACHINES.

One 20-h.p. motor driving a planer.
One 13-h.p. motor direct connected to 600-ton wheel press.
One 7½-h.p. motor for moving tail-stock of driving wheel lathe.

VARIABLE SPEED MOTOR-DRIVEN MACHINES.

One 7½-h.p. motor operating vertical miller for side rods.
One 20-h.p. and one 6-h.p. operating 90-in. boring mill.
One 20-h.p. motor operating driving axle lathe.
One 7½-h.p. motor operating crank pin lathe.
One 40-h.p. motor operating 90-in. driving wheel lathe.
One 25-h.p. motor driving truck tire lathe.

With the variable speed motors it is possible to increase the output, as the time and labor necessary to shift belts or



MOTOR-DRIVEN VERTICAL MILLING MACHINE.

change mechanical speed devices is minimized, and a piece of work can be machined continuously from the smallest to the largest diameter without interruption.

The speed of these motors is controlled by varying the field strength, and, as this may be done while the machine is in operation, it affords an easy and convenient method of speed regulation always under the immediate control of the operator, the controller being conveniently placed within his reach. The variation of field strength is effected by means of a resistance placed in the shunt field circuit of the motor, which decreases the shunt field current and causes a decrease in the field strength and an increase in speed, producing an extremely simple and effective means of varying the speed of either a shunt or a compound-wound motor.

One of the most prominent characteristics of this method of control is the simplicity and low cost of control apparatus made possible by the extremely small current which is handled. A second marked characteristic is the increase of speed with decrease of torque, when used as an adjustable speed motor, the horse-power output remaining practically constant throughout the whole speed range, which makes it peculiarly adapted to machine tool driving. This system involves the use of a minimum amount of auxiliary apparatus, thus materially reducing the first cost of an installation. The regulation of motors operating by shunt field control is good, which is of special importance in the operation of machine tools and in service of any class where constant speed is desirable and where the torque varies between wide limits. The efficiency of motors operating at variable speeds remains practically constant over the range of speed.

The list of machine tools and motors for the other departments is as follows:

TOOL ROOM—20-H.P., CONSTANT SPEED, TYPE S MOTOR.

Yankee twist drill grinder.	Crank planer, 15x15x20 in.
Duplex emery grinder (8-in. wheels).	Lathe, 16 in.
No. 4 universal milling machine (Brown & Sharpe).	No. 3 Landis universal grinding machine.
No. 4 universal milling machine (Cincinnati Milling Machine).	Sellers tool grinder.
	Reamer and cutter grinder.
	Gardner disc grinder.

CARPENTER SHOP—50-H.P., CONSTANT SPEED, TYPE S MOTOR.

Hollow chisel mortiser and boring machine.	Rip saw, 12 in.
Gaining machine.	Hand saw, 42 in.
2-Spindle shaper.	Cutting-off saw, 12 in.
Moulding machine.	Single horizontal borer.
Daniels' planer, 24x14 in. x 9 ft.	Tenoning machine.
Plain mortiser and borer.	Turning lathe, 15 in.
Planer, 8x14 in., 3 cutters.	Swing vertical borer, 15 in.
Rip saw, 18 in.	Pipe cutter, 4 in.
	Pipe cutter, 3 in.

BLACKSMITH SHOP—30-H.P., CONSTANT SPEED, TYPE S MOTOR.

2-Power hammers.	Bolt header, 2½ in.
Light bar shear.	Alligator shears.
Small bolt header.	Bar iron shears.
Bolt header, 1½ in.	Hot saw.

50-h.p. constant speed type S motor direct connected to No. 9 Sturtevant fan.

BOILER SHOP—7½-H.P., CONSTANT SPEED, TYPE S MOTOR.

Two Hartz flue welding machines. Two flue cutting machines.

DIRECT-DRIVEN MACHINES OPERATED BY CONSTANT SPEED, TYPE S MOTORS

One 7½-h.p. motor driving 20 in. punch and shears.
One 25-h.p. motor operating plate rolls.
One 10-h.p. motor operating horizontal punch.
One 7½-h.p. motor driving bevel shears.
One 10-h.p. motor operating 36 in. punch and shears.

In connection with the boiler shop equipment there is a flue rattler, located outside the building, and operated by a 20-h.p. type S motor. It is 48 ins. in diameter and 22 ft. long, and has a capacity of 175 to 200 flues. An average of five lots per day are cleaned, the exact time for each rattling depending upon the water used in the boilers. The longest flue is 21 ft., and they vary from 1½ to 2½ ins. in diameter.

TANK SHOP—20-H.P., CONSTANT SPEED, TYPE S MOTOR.

Single shear, 36 in.	Single punch, 36 in.

In addition to the belt-driven machines there is a 10-h.p. and a 15-h.p. constant speed type S motor geared to a plate roll.

ROUNDHOUSE MACHINE SHOP—20-H.P., CONSTANT SPEED TYPE S MOTOR.

Engine lathe, 16 in.	Upright drill, 40 in.
Engine lathe, 26 in.	Duplex emery grinder.
Planer, 32x32 in. x 8 ft.	Arbor press, 15-ton.
Pillar shaper, 24 in.	

MISCELLANEOUS APPLICATIONS.

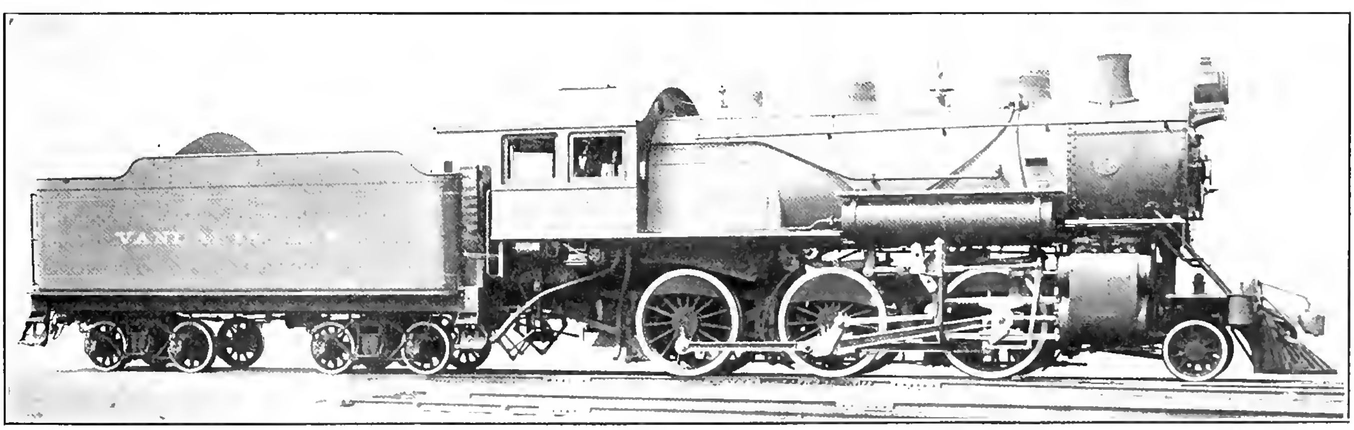
One 70-h.p. Westinghouse type S constant speed motor driving fan for round house heating system.
One 10-h.p. Westinghouse type S constant speed motor driving fan for new erecting shop heating system.
One 7½-h.p. variable speed Westinghouse type S motor operating round house turntable.
One 50-h.p. constant speed motor operating coal conveyer in locomotive coaling station.
One 30-h.p. constant speed Westinghouse type S motor operating ash conveyor for removing ashes from locomotive ashpit.
One 7½-h.p. Westinghouse motor operating alligator shears for cutting up sheet iron. This installation is located at the scrap bins in the shop yards.
One 25-h.p. motor operating transfer table.

The preliminary studies and final report, showing the benefits which would be the result of electrically equipping these shops, were made by the Westinghouse Electric & Manufacturing Company in conjunction with the motive power department of the Erie Railroad. The results have more than borne out the promises made to the management. The installation of the new electrical equipment presented many engineering problems, but the work of transformation was carried on without any interruption to the service, and it reflects great credit to the contractors, Westinghouse, Church, Kerr & Company, who installed the plant, and Mr. George T. Depue, master mechanic of the Erie Railroad Company, who has charge of the Hornell shops.

HEAVY MOGUL FREIGHT LOCOMOTIVE WITH WALSCHAERT VALVE GEAR.

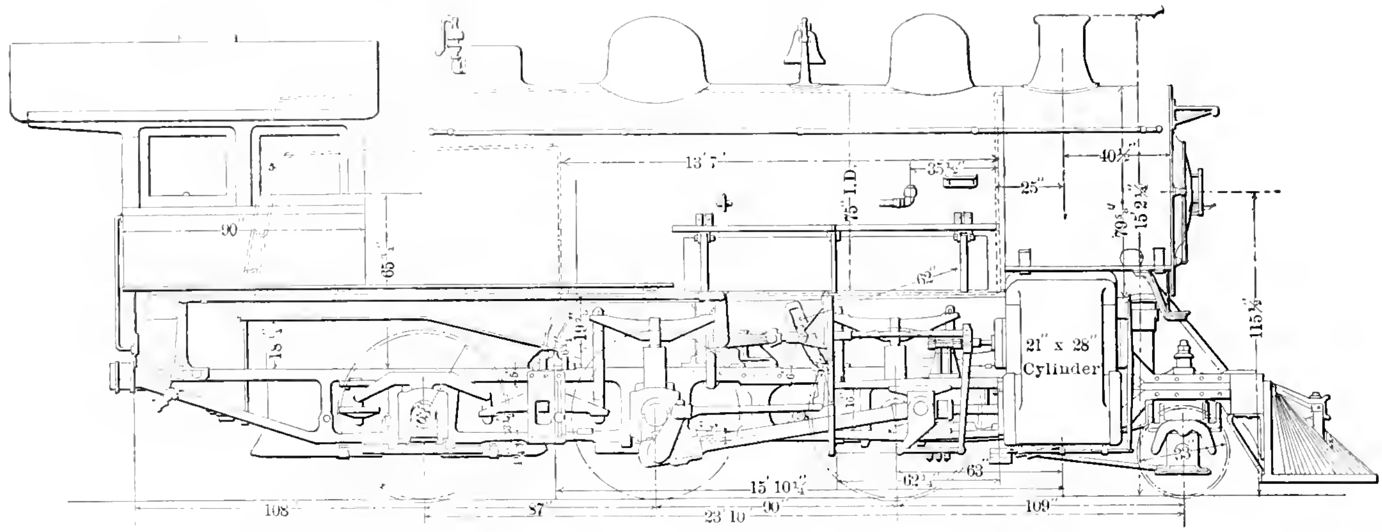
VANDALIA RAILROAD.

The American Locomotive Company has recently delivered an order of three very heavy Mogul freight locomotives to the Vandalia Railroad, one of which is illustrated herewith. These locomotives are the heaviest of their type ever built, and with the exception of some six-wheel switching engines recently built for the Pittsburgh & Lake Erie Railroad, which were illustrated in this journal in September, page 346, they have the heaviest weight on three coupled drivers of any locomotives ever built by this company. This exception, however, does not include the Mallet articulated compound built for the Baltimore & Ohio Railroad, which has two sets of three coupled drivers, and gives an average weight of 55,700 lbs. per axle. The Mogul engines have a weight per axle of 53,100 lbs., and a total weight of 187,000 lbs.

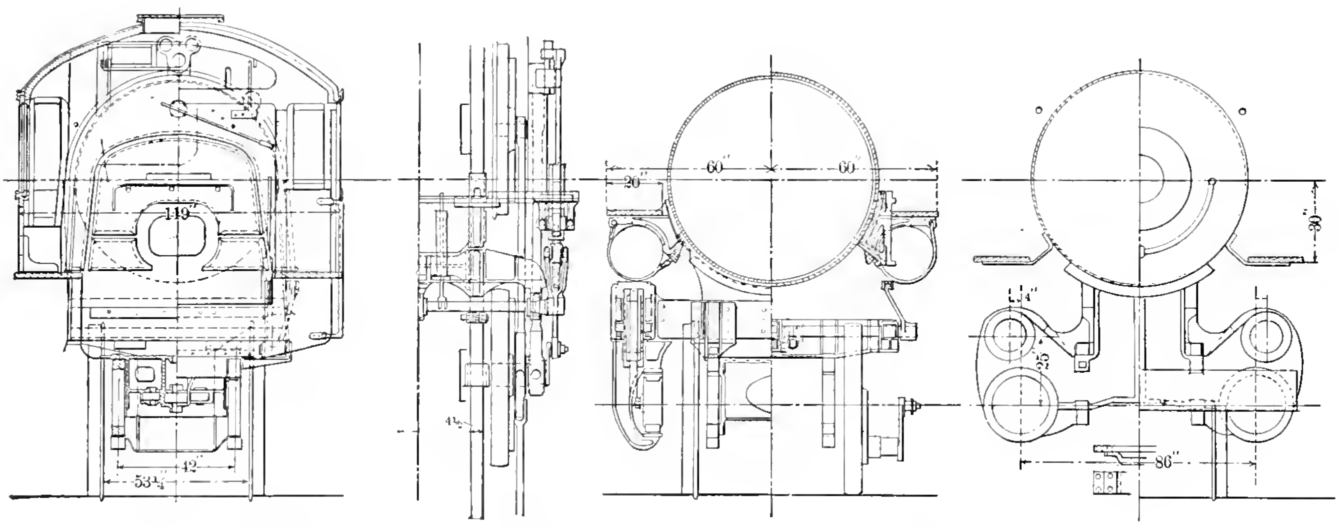


2—6—0 TYPE FREIGHT LOCOMOTIVE WITH WALSCHAERT VALVE GEAR—VANDALIA RAILROAD.

A few years ago the 2—6—0 type locomotive was very popular in many sections of the country for freight service, but recently with the general demand for the heaviest possible locomotives that track and bridge conditions would permit there have been comparatively few of this type ordered. The



SIDE ELEVATION OF 2—6—0 TYPE LOCOMOTIVE—VANDALIA RAILROAD.



SECTIONS AND PLAN OF VALVE GEAR, 2—6—0 TYPE LOCOMOTIVE—VANDALIA RAILROAD.

type should not by any means be considered obsolete, and within its limits, for freight service it probably offers the best possible arrangement of boiler and machinery for the power developed.

The accompanying table shows locomotives of the four different types now in general use for freight service, each example of which has approximately the same tractive effort. A study of the table, giving particular attention to the important ratios, will show that the 2—6—0 type is not out of the race. This particular example, of course, is very heavy on drivers and has a very large boiler.

The three locomotives in this order which are known in the railroad company's classification as Class VF5A, are similar in size, dimensions and general arrangement to 18 other locomotives, Class VF5, which have been in service since 1903 and 1904. The differences made in this later order consist in the use of the Walschaert valve gear instead of the Stevenson and piston instead of slide valves. These changes have resulted in an increase of weight, making them 4,500 lbs. heavier than the previous class.

These engines have been designed for use in mixed service, although it is expected that they will operate principally in freight service on the St. Louis division between Indianapolis and East St. Louis, which division is single tracked, with a maximum grade of 1 per cent., and a greater part of the freight traffic is moved over it as fast freight. Of the 18 engines in the Class VF5 nine were used in passenger service during the year 1904 and nine in freight service. The latter made an average of 50,163 miles and a maximum of 58,611 before receiving general repairs, and the former nine made an average of 75,858 miles and a maximum of 94,658 miles. The three locomotives with Walschaert valve gear have now been in operation four months, and are reported to be giving very satisfactory service. They ride somewhat better than the previous engines, due to the slightly increased weight on the engine truck and front drivers, and work smoother at higher speeds.

Type	2-6-0	2-8-0	4-6-0	2-6-2
Owner	Vandalia.	B. & M.	C. P. R.	N. P.
Tractive effort, lbs.	33,300	33,400	33,300	33,300
Total weight, lbs.	187,000	170,000	190,000	209,500
Weight on drivers, lbs.	159,300	148,000	141,000	152,000
Weight per driving axle, lbs.	53,100	37,000	47,000	50,666
Diameter, drivers, ins.	63	61	63	63
Size cylinders, ins.	21x28	20x30	21x28	21x28
Steam pressure, lbs.	200	200	200	200
Total heating surface, sq. ft.	2,935	2,861	2,413	2,726*
Grate area, sq. ft.	52	46.5	49.5	43.5
Length of flues, ft. & ins.	13-7	16	14-2⅞	15-11*
Driving wheel base, ft. & ins.	14-9	17	14-10	11
Total wheel base, ft. & ins.	23-10	25-6	26-1	28-11
Weight on driv. ÷ total weight per cent.	85.2	87	74.2	72.5
Weight on driv. ÷ tractive effort	4.77	4.43	4.24	4.57
Total weight ÷ tractive effort	63.8	59.4	78.7	76.6
Total weight ÷ total heating surface	5.6	5.1	5.7	6.3*
Firebox H. S. ÷ total H. S. per cent.	6.15	5.03	7.45	7.8*
Tractive effort x diam. driv. ÷ total heating surface (B. D.)	715	711	870	762*

*The boiler of this locomotive has a combustinn chamber 32 ins. long, but for the purpose of getting a more accurate comparison with the other locomotives not so fitted, it has been assumed that this space is filled with flues in the usual manner.

Although the length of service has not yet been sufficient to prove whether the advantages of the Walschaert valve gear are sufficient to warrant its general application to this type of locomotive, still its application in this case can be taken as an indication that the advantages of a valve gear outside of the frame are being appreciated, since with this type of locomotive a simple form of Stevenson gear without complications is permissible.

The Walschaert gear is designed to give straight line motion with the combination lever on the outside of the guides, and the valve chamber is set 4 ins. outside of the center of the cylinder for this purpose. The lifting arm connects to the radius rod through a slip joint, making a very simple and satisfactory arrangement. The extension of the valve stem is guided by a support from the top guide bar.

A study of the illustrations will make clear the other details of the locomotive, which as a type has been the standard freight locomotive on this road since 1896. The general dimensions, weights and ratios are as follows:

SIMPLE MOGUL FREIGHT LOCOMOTIVE.

VANDALIA RAILROAD.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bituminous coal
Tractive effort	33,300 lbs.
Weight in working order	187,000 lbs.
Weight on drivers	159,300 lbs.
Weight on leading truck	27,700 lbs.
Weight of engine and tender in working order	333,000 lbs.
Wheel base, driving	14 ft. 9 in.
Wheel base, total	23 ft. 10 in.
Wheel base, engine and tender	56 ft. 10¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.77
Total weight ÷ tractive effort	5.6
Tractive effort x diam. drivers ÷ heating surface	715
Total heating surface ÷ grate area	56.5
Firebox heating surface ÷ total heating surface, per cent	6.15
Weight on drivers ÷ total heating surface	54
Total weight ÷ total heating surface	63.8
Volume both cylinders	11.2 cu. ft.
Total heating surface ÷ vol. cylinders	262
Grate area ÷ vol. cylinders	4.65
CYLINDERS.	
Kind	Simple
Diameter and stroke	21 x 28 in.
VALVES.	
Kind	Piston
Greatest travel	6 in.
Outside lap	1¼ in.
Inside clearance	⅛ in.
Lead in full gear	3/16 in.
WHEELS.	
Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	9½ x 12 in.
Driving journals, others, diameter and length	9½ x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6½ x 12 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	76⅝ in.
Firebox, length and width	108⅛ x 69¼ in.
Firebox plates, thickness	C-7/16, T-½, S. & B. ⅜ in.
Firebox, water space	F-4½, S. & B. 4 in.
Tubes, number and outside diameter	390-2 in.
Tubes, length	13 ft. 7 in.
Heating surface, tubes	2,754.6 sq. ft.
Heating surface, firebox	180.4 sq. ft.
Heating surface, total	2,935 sq. ft.
Grate area	52 sq. ft.
Smokestack, diameter	16 & 17½ in.
Smokestack, height above rail	15 ft. 3 5/16 in.
TENDER.	
Tank	Water bottom
Frame	2-12 in. & 2-10 in. channels
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,500 gals.
Coal capacity	13 tons

It is not how well a man can do the work himself, but how well he can direct others to do it.—*Paul R. Brooks, before the New York Railroad Club.*

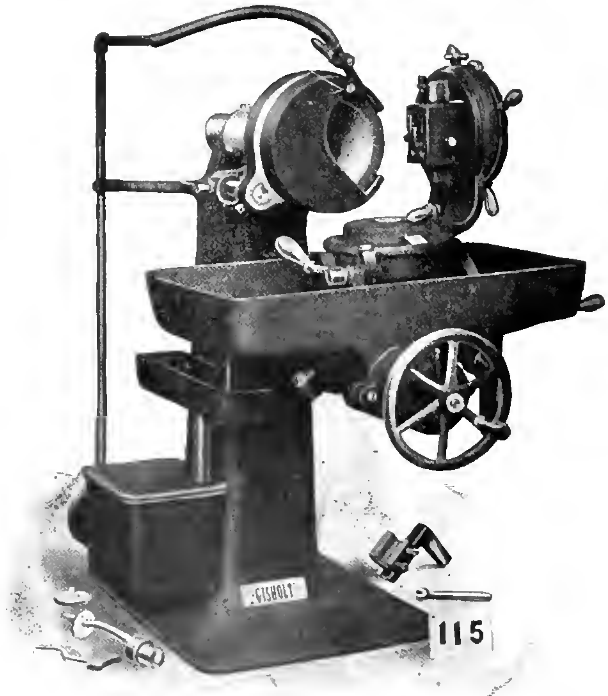
RAPID UNLOADING.—The steamer Powell Stackhouse with a cargo of 9,700 tons of soft coal was unloaded recently at the docks of the Milwaukee Coke & Gas Company by two Brownhoist steam rigs equipped with 2-ton grab buckets in 39 hours actual working time, an average of 249 tons per hour, or 124½ tons per hour per rig. The unloading of the entire cargo, including the cleaning up, was done by grab buckets, and for the first ten hours each machine averaged 160 tons per hour.

GRINDING LATHE AND PLANER TOOLS.

The matter of correctly grinding tools is one that is receiving more and more attention in the better organized shops, where the importance of systematically caring for the cutting tools is fully appreciated. Tool grinding is considered just as much of a department or specialty as the operation of any machine or the maintenance of any department. To have the machine tool operators constantly leaving their machines to sharpen tools is no longer considered the best practice.

There are many excellent reasons for making a department for this class of work. In the first place, the matter of establishing and maintaining correct grinding angles for the various tools is of the utmost importance, in order that they may turn out a maximum amount and high grade of work. It is a well-known fact that there are certain angles for every tool that will produce the best results, and it is practically impossible to maintain these angles unless some method is followed in grinding the tools, and whereby a department is made responsible for the maintenance of such angles. Tools cannot be ground and the best results obtained by the old method of every operator doing his own grinding. While many operators are very skillful in shaping cutting tools, yet the time of such men is much more valuable in operating the machine than in sharpening the tool, especially where the cutting tool can be correctly ground by machine. Tool grinding does not call for the most expert work when done on a tool grinder that is simple in its operation.

Leaving a machine tool idle in order to grind tools means not only a loss in output, but a considerable increase in the cost of the article produced. As the expense to the company, including surcharges, for a machine and operator usually averages about one dollar per hour, the importance of form-



GISHOLT TOOL GRINDER.

ing a department for the maintenance of the cutting tools is apparent. Under the old system there is the further difficulty of the operator not being able to use the grinder immediately, but having to stand in line waiting for two or three others to finish before he can use it.

Other excellent reasons for the establishment of a tool grinding system may briefly be enumerated as follows:

Will grind tools more quickly.

Gives tools that are correctly ground.

Tools cut better—faster.

Increases the output of machine tools.

Machine ground tools are easier to sharpen.

Comparatively cheap labor may be used for grinding them.

Does away with having a lot of unused tools lying about and getting lost.

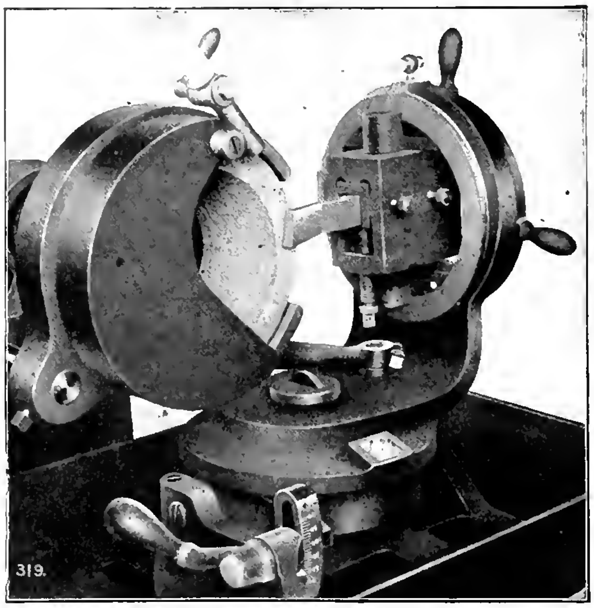
Makes it so simple to get sharp tools that there is no excuse for the workmen using dull ones and consequently injuring the output.

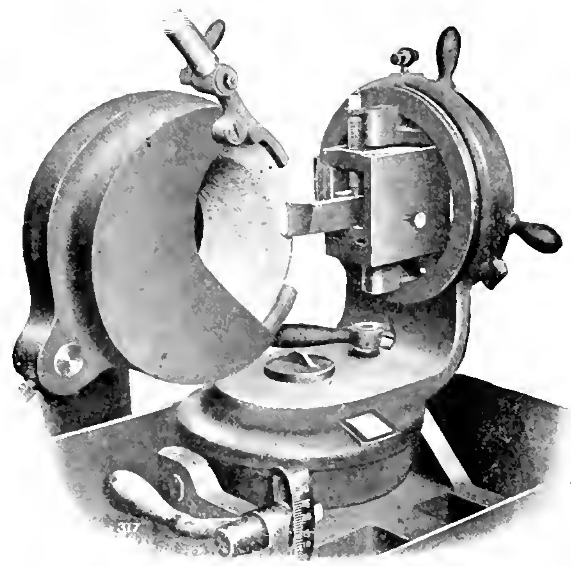
Makes an annual saving in dollars and cents that will cover the cost of the grinder in a surprisingly short time.

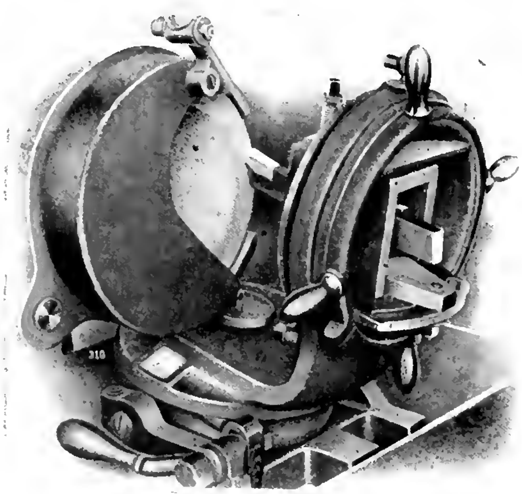
To meet the requirements for a moderate priced tool grinder and a machine that will grind lathe and planer tools quickly and accurately, the Gisholt Machine Company of Madison, Wis., has placed on the market the machine illustrated herewith. This grinder is not a new machine, a large number of them being in operation both in this country and in Europe.

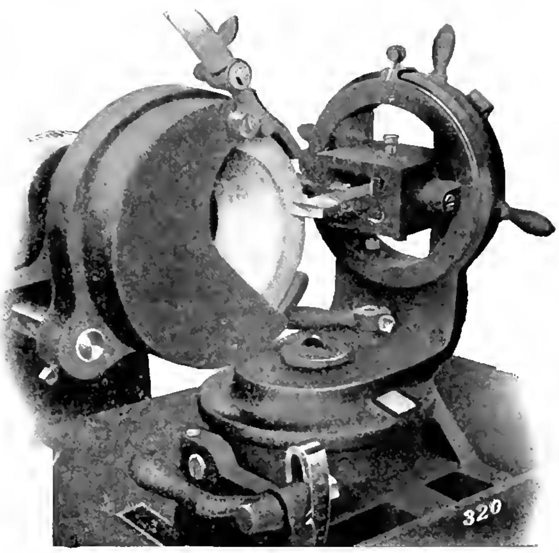
The machine is a simple one to operate. Briefly described, there is a cup emery wheel mounted directly on the spindle of the machine. Just below this is a large pan. Mounted in the pan is a tool holder in which the tool is clamped the same as it would be in the lathe or planer. This pan has two movements—one to and from the main column of the machine, actuated by a hand wheel—the other an oscillating motion of the pan about the axis of the hand wheel, for traversing the tool across the face of the wheel. This motion is obtained by an up-and-down movement of the handle shown to the right of the pan. In order to obtain the correct angles for the standard lathe and planer tools, the Gisholt Company has prepared a chart giving the correct angles, which is sent out with each tool grinder. They also provide, when desired, a set of fifty-seven sample tools correctly ground, for guidance in grinding and in forging.

The first operation in grinding a tool is to clamp it in the tool holder as shown in the illustration. This tool holder has a universal movement, so that the tool may be set to get the proper angle on the side, end, top or face as the case may be. There are four graduated scales. Reference to the chart gives the various angles required for a given side, and upon being set to these angles the tool is traversed up to the wheel by means of the hand wheel which is operated by the left hand. The tool is traversed across the face of the wheel by means of the lever operated by the right hand. It is not removed from the tool holder until all the faces are ground.


FIRST OPERATION.

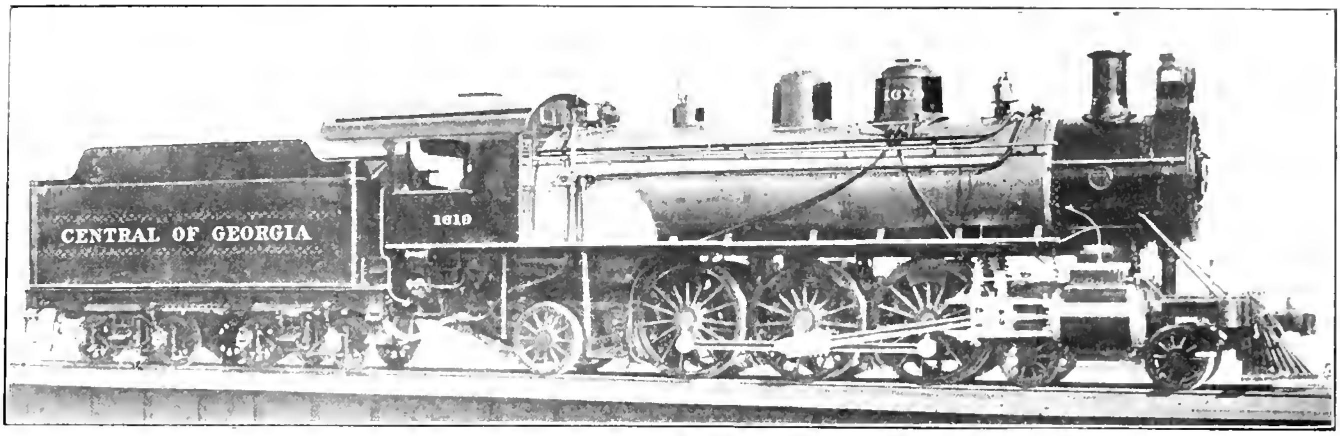

SECOND OPERATION.


THIRD OPERATION.

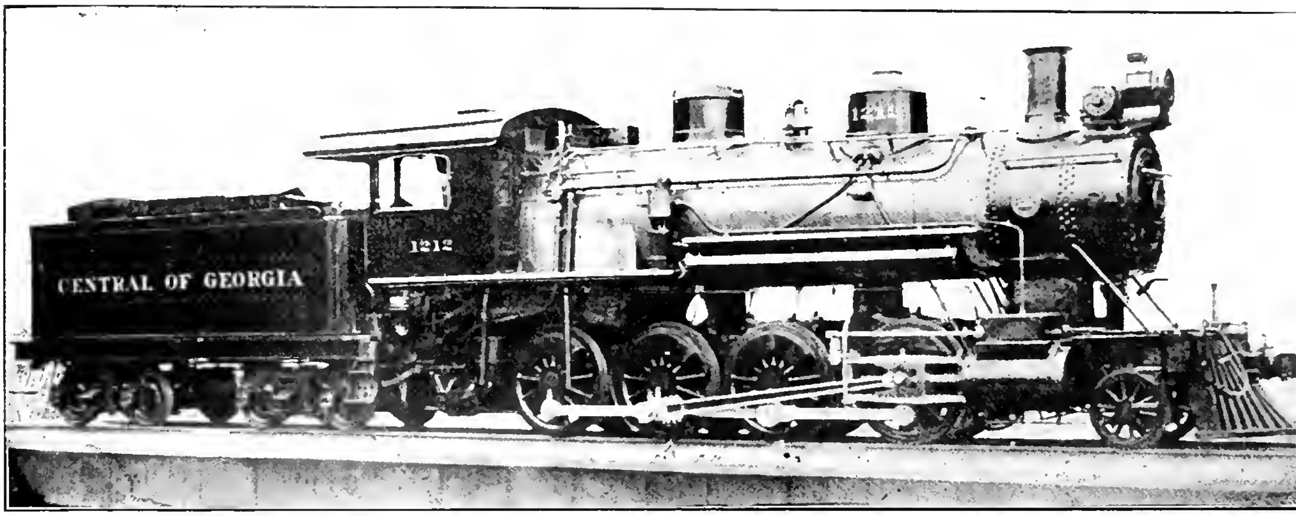

FOURTH OPERATION

Another important matter in handling the tool problem is the question of correct forging. In order to assist the smith in getting the correct shapes, a set of blocks known as formers are furnished with each Gisholt grinder. By the use of these nearly all of the usual shapes of lathe and planer tools may be formed, thus reducing the time required for forging to a minimum.

The Vanderbilt system of railroads comprises 21,353 miles of line and the Hill system 20,242 miles.



PACIFIC TYPE PASSENGER LOCOMOTIVE—CENTRAL OF GEORGIA RAILWAY.



CONSOLIDATION TYPE FREIGHT LOCOMOTIVE—CENTRAL OF GEORGIA RAILWAY.

PASSENGER AND FREIGHT LOCOMOTIVES.

CENTRAL OF GEORGIA RAILWAY

The Central of Georgia Railway has recently received from the Baldwin Locomotive Works an order of ten Pacific and fifteen consolidation type locomotives. The former are designed for passenger service, and have a tractive effort of 28,000 pounds. As the weight on the driving wheels is 113,660 pounds the factor of adhesion is 4.06. These engines are well proportioned throughout, and have ample boiler power for the service required of them.

The boiler is of the straight top design, with sloping throat sheet and back head. The barrel is supported by the guide bearer sheets and two intermediate waist sheets. The fire-box is carried at each end on buckle plates bolted to cross ties. Both injectors are located on the right side, and feed through a double check valve placed on the top of the boiler close to the front tube sheet.

The cylinders are equipped with slide valves, actuated by the Stephenson link motion. The rock shaft is placed immediately in front of the leading pair of driving wheels, and is connected to the link block by a transmission bar, which spans the leading driving axle.

The frames are of cast steel, with double front rails and separate rear sections. The rear truck is of the Rushton type, with inside journals.

The tender frame is built of 12-inch steel channels. The tank is U-shape, with a water bottom and a sloping floor in the fuel space.

In the consolidation engines the details are as far as possible interchangeable with those of the Pacific type. The tractive effort is 34,000 pounds, and the factor of adhesion is 4.21. The boilers are of the wagon top design, and are smaller than those used on the passenger locomotives. The fire-boxes are supported in a similar manner.

On these freight locomotives the link is suspended immediately back of the second driving axle, and the rock shaft is between the first and second pairs of driving wheels. The transmission bar passes above the intermediate axle. The leading truck is equalized with the first and second pairs of driving wheels. The third and fourth pairs of wheels are equalized by beams placed over the boxes and connected through an inverted leaf spring. Coiled springs are used to support the frame at the other ends of the beams.

The tender is similar to that used on the Pacific type locomotives, although the fuel and water capacity is less.

The general weights, dimensions and ratios of both classes are as follows:

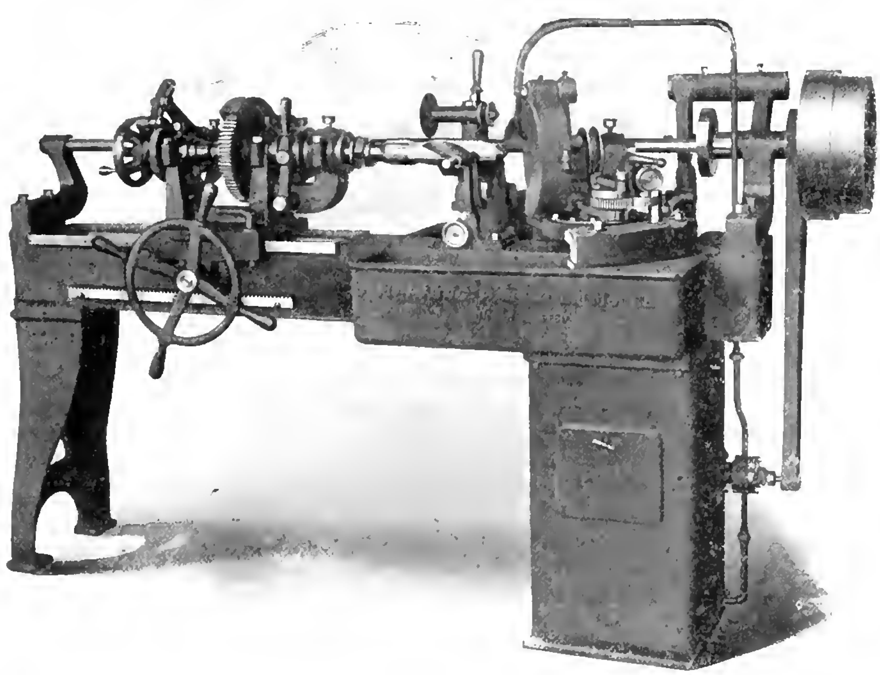
GENERAL DATA.		
Type	4-6-2	2-8-0
Service	Pass.	Frgt.
Fuel	Bit. Coal.	Bit. Coal.
Tractive effort	28,000 lbs.	34,000 lbs.
Weight in working order	187,860 lbs.	163,390 lbs.
Weight on drivers	113,660 lbs.	143,290 lbs.
Weight on leading truck	37,300 lbs.	20,100 lbs.
Weight on trailing truck	36,900 lbs.	....
Weight of engine and tender in working order	335,000 lbs.	283,000 lbs.
Wheel base, driving	11 ft. 10 in.	16 ft.
Wheel base, total	30ft. 4 ½ in.	24ft. 3½ in.
Wheel base, engine and tender	58ft. 5½ in	53ft. 9 in.
RATIOS.		
Weight on drivers ÷ tractive effort	4.06	4.21
Total weight ÷ tractive effort	6.7	4.8
Tractive effort x diam. drivers ÷ heating surface	568	825
Total heating surface ÷ grate area	71.8	52.5
Firebox heating surface ÷ total heating surface, per cent	5.05	6.35
Weight on drivers ÷ total heating surface	33.8	62.
Total weight ÷ total heating surface	56.	71.
Volume both cylinders	10.2 cu. ft.	10.2 cu. ft.
Total heating surface ÷ vol. cylinders	331.	227
Grate area ÷ vol. cylinders	4.62	4.33
CYLINDERS.		
Kind	Simple.	Simple.
Diameter and stroke	20x28 in.	20x28 in.
Kind of valves	Bal Slide.	Bal. Slide.

WHEELS.		
Driving, diameter over tires	68 in.	56 in.
Driving, thickness of tires	3 in.	3 in.
Driving journals, main, diameter and length	9x12 in.	8½x10 in.
Driving journals, others, diameter and length	8½x12 in	8½x10 in.
Engine truck wheels, diameter	33 in.	33 in.
Engine truck, journals	5½x10 in.	5½x10 in.
Trailing truck wheels, diameter	42 in.	.. ..
Trailing truck, journals	7½x12 in	.. ..
BOILER.		
Style	Str.	W. T.
Working pressure	200 lbs.	200 lbs.
Outside diameter of first ring	66 in.	61 in.
Firebox, length and width	102¾x66 in.	96⅛x66 in.
Firebox, water space	F-4,S&B-3½in	F-4,S&B-3in
Tubes, number and outside diameter	280-2¼ in.	283-2 in.
Tubes, length	19 ft. 5 in.	14 ft. 8 in.
Heating surface, tubes	3188 sq. ft.	2161 sq. ft.
Heating surface, firebox	169.5 sq. ft	146 sq. ft.
Heating surface, total	3357.5 sq. ft	2,307 sq. ft.
Grate area	46.8 sq. ft.	44 sq. ft.
TENDER.		
Tank	U.	U
Frame	12 in. chan.	12 in. chan.
Wheels diameter	33 in.	33 in.
Journals, diameter and length	5½x10 in.	5½x10 in.
Water capacity	7,500 gals.	6,000 gals.
Coal capacity	12 tons	8 tons

DAHL AUTOMATIC DRILL GRINDER.

The Dahl automatic drill grinder, illustrated herewith, was developed in Europe and is being introduced and manufactured in this country by Manning, Maxwell & Moore. It works automatically, may be operated by unskilled labor and will grind accurately drills from ½ to 3½ ins. in diameter.

The drill while being ground is fed toward the grinding wheel and revolves slowly. The carriage or head upon which the grinding wheel is mounted has a peculiar motion imparted to it by the large cam on the main shaft, to the left of the driving pulley. This motion is carefully designed to accurately grind the proper clearance. With such an arrangement it is, of course, necessary to have both the drill and the grinding wheel carriage operated positively from the same driving shaft and also to have the drill set accurately. The latter is accomplished by means of the pointer or gauge shown in front of the drill to the left of its cutting end. The grinding wheel head or carriage also feeds slowly back and forth so that the wear on the face of the wheel is uniform. Gauges are placed upon this head for adjusting the wheel for various diameters and there is also a micrometer adjustment for adjusting the wheel as it wears.



DAHL AUTOMATIC DRILL GRINDER.

The drill chuck is operated by a lever and securely grips the drill, holding it true. Motion is transmitted to the drill spindle by a small gear on the driving shaft which meshes with the large gear shown in the illustration. The drill spindle carriage may be rapidly traversed by the large hand wheel in front or in order to properly adjust the drill before throwing on the power feed it may be slowly and carefully traversed by the small hand wheel at the end of the carriage. The feed arrangement is such as to provide a wide range and to afford a fine adjustment.

After the drills are ground the drill carriage is moved back a short distance and the small emery wheel shown just back of the drill is swung around 90 degs. and the drill is pointed. Both of the grinding wheels are driven from the countershaft by separate belts. The pump, which circulates the water or lubricant contained in the two large pans either side of the grinder head is driven from the driving shaft as shown. The machine weighs about 1,900 lbs.

Labor Conditions on the Panama Canal.—The kind and quality of mechanics it was necessary to depend upon for the first fifteen months were exceedingly annoying, as the men had been gathered up from what had been left by the French, and also from South and Central America, speaking various languages. Within the past year, however, a very good grade, on the average, of American mechanics has been employed. As the mechanics in the United States are finding out that the sanitary conditions on the Isthmus are nothing like as represented by the majority of the current publications, and, further, that such conditions are no worse, and in many instances better, than are found in our own South below the city of Memphis, Tenn., a very satisfactory class of these men have taken up their homes on the Isthmus.

The rates of pay of the various employes are as follows: Steam shovel engineers, $210 per month; steam shovel cranesman, $180; locomotive engineers (construction work), $125; drill runners, $180; trainmen, $100; conductors, $150; foremen of dumps, $125; powdermen, $100; shop foremen, $150 to $175; general foremen, $200 to $225. All monthly employes are transported from New York to Colon free of charge, and their pay commences at the hour when the vessel leaves the pier at New York. In addition, all monthly employes are entitled to six weeks' leave of absence each year with pay, together with the $20 rate to New York, going and coming. They are also still further entitled to 30-day sick leave, with pay in addition when actually sick.

Skilled labor, paid by the hour, is rated as follows: All classes of machinists, boilermakers, blacksmiths and moulders receive 65 cents per hour; plumbers, 75 cents; carpenters, planing mill machine hands, coach cabinet makers, 56 cents; blacksmith helpers and car inspectors and repairers, 44 cents. At the present time the working hours are eight per day. Men employed by the hour are given free transportation from New York, their time of employment commencing when vessel leaves. These are not, however, entitled to any special privileges, such as leave of absence with pay.

Living quarters are furnished to all men arriving on the Isthmus, consisting of a room, with bed, mattress and pillow, but the employes are expected to furnish all linen, blankets and mosquito bar. Excellent board is furnished at the hotels of the Commission at 30 cents per meal, making boarding expenses total about $27 per month.

All hotels and quarters furnished for men are either new, or old French quarters thoroughly and generally overhauled.

Desirable and competent men, who are making up their minds to stay, are encouraged to bring their families down. Comfortable quarters are furnished to each family. New

quarters are being furnished as rapidly as the buildings can be erected. At the present time, all points where American skilled labor is located are being furnished with a good and reliable water supply and a convenient commissary run by the government. A full variety of provisions at a trifling advance over the cost of such provisions in the States can be obtained. The slight extra cost is simply to make the commissary self-supporting.

As regards a man's physical condition, there is no reason why one who is free from any kidney or liver troubles would not be as safe in working on the Isthmus as almost anywhere in our own Southern States. An age limit for skilled mechanics has been established at from 21 to 45 years.

The climatic conditions, while annoying during five or six months of the year, owing to the heavy rains, are troublesome only as regards the work, by causing slides and bad track. While the atmosphere during the rainy season is very humid, this condition is due to moisture from the two oceans and is decidedly different from the humidity in our interior States. Temperature conditions vary in the shade from 80° to 87° Fahr. Under cover a breeze can always be felt, and the use of a blanket after one or two o'clock every night in the year is decidedly necessary. It can thus readily be seen that the average conditions on the Isthmus are such as would favorably appeal to even the most skeptical of American workmen.—*Charles W. Burke, in the Engineering Record.*

A 40-TON STEEL FLAT CAR for carrying boilers, large castings, etc., has recently been built for the Cheshire Lines, of England, and is peculiar in that (like some other English cars for the same purpose) the floor is dropped between the trucks. There are four 9-in. I-beam sills, reinforced by top and bottom cover plates, and having a total length of 46 ft. 9 ins. The two sills on each side are connected at each end by a cross connection, the middle of which is carried in a link or hanger supported from bearings on the truck frame. Cross pieces are riveted between the sills at intervals, and the outer sills have a number of rings for securing the chains or lashings. The height from the rail to the floor is only 20½ ins. The trucks have four wheels 4 ft. 6 ins. diameter, on a wheel-base of 6 ft. 3 ins., and have semi-elliptic springs over the boxes, but the springs are not equalized. Transverse frames or bulkheads prevent the load from fouling the trucks. With a total capacity of 40 tons, the car will carry 25 tons on a length of 12 ft. at the middle. The car is 59 ft. long over the buffers, with trucks 44 ft. 9 ins. c. to c., and 32 ft. clear length of floor. The journals are 5½ x 8 ins. The car is equipped only with a hand brake, and that operates brakeshoes on only one pair of wheels.

FLUCTUATING FORCE UNECONOMICAL.—The industrial world has found that machinery is most economical when continuously operated. The human portion must be considered as one machine in the aggregate. The more uniform it is maintained the greater its efficiency. In a fluctuating force poor men come and good men go. A smaller number of men kept continuously at work under a definite appropriation, which takes full advantage of the long summer days to get equipment in shape for the winter, will show a better annual balance sheet. The reason that expenses go up when the gross receipts do is that they were previously forced down with the gross receipts.—*Paul R. Brooks, before the New York Railroad Club.*

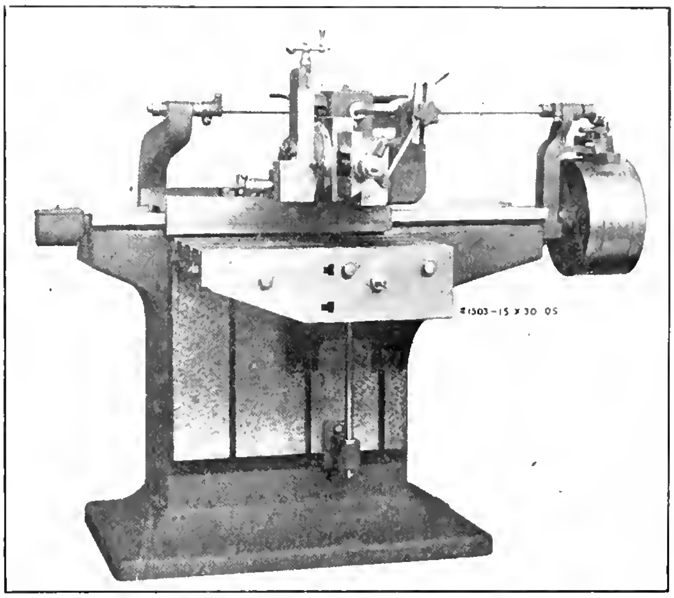
ONE BOILERMAKERS ASSOCIATION.—The International Railway Master Steam Boilermakers Association and the Master Steam Boilermakers Association will meet in joint convention at Cleveland, Ohio, May 21, 22 and 23, 1907, to organize into a single large association of foreman boilermakers. It is expected that the new association will be very much more effective than the separate organizations.

OPEN SIDE SHAPER OR PLANER.

The Cincinnati Shaper Company has recently brought out a line of open side planers, the smallest of which is shown in the accompanying illustration, and planes 15 ins. wide and 30 ins. long. It is of an improved Richards type, and for certain classes of work may be used to better advantage than either a pillar shaper, a traverse shaper or a planer. The leading dimensions of the machine illustrated are as follows:

Length of stroke	30 in.
Width planed	15 in.
Maximum distance head to table	15½ in.
Minimum distance head to table	4½ in.
Vertical adjustment of table	11 in.
Length of table and extension	30 in.
Width of table	18 in.
Depth of table	12 in.
Down movement of tool slide	6½ in.
Ratio of cut to return	1 to 2
Weight of machine and countershaft, net	3,450 lbs.

The machine is driven by a single screw and bronze nut, and without the intervention of gears. The screw is 2⅛ ins. in diameter and is made of .50 carbon steel. The saddle has a long and wide bearing on the column, with a narrow and



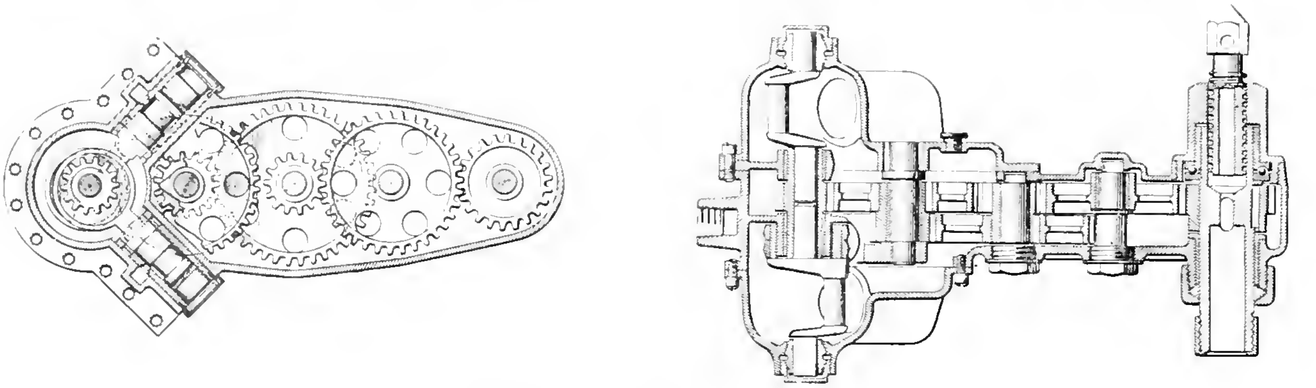
OPEN SIDE SHAPER OR PLANER

deep guiding surface to prevent binding, especially when the tool is at the outer end of the rail. It is provided with a taper gib lengthwise, adjustable by screws at each end, affording uniform contact on both sides of the gib.

The cross feed by power or by hand, is positive and adjustable. The down feed is by hand. The reversing mechanism is new and a decided improvement over existing methods. It depends on the turning of the shifting rod both for reversing the motion of the saddle and for the automatic cross feed to the head, the rod being automatically turned by cams on the saddle coming in contact with dogs adjustable on the rod, or by hand from the saddle, if desired.

There are ball bearings for the shifting rod, as well as under the table elevating screw. There are taper gibs to the cross rail and to the head. The head has a down feed of 6½ ins., swivels, is graduated, and has a micrometer collar reading to .001 ins. The table raises and lowers by means of a crank handle, not shown. The supplementary table may be removed, to bolt pieces against the side of the table proper, or the table itself removed and pieces bolted directly to the column. Keyseating of shafting of any diameter may be done in the machine. All flat bearings are hand scraped to surface plates, and all tee slots cut from the solid.

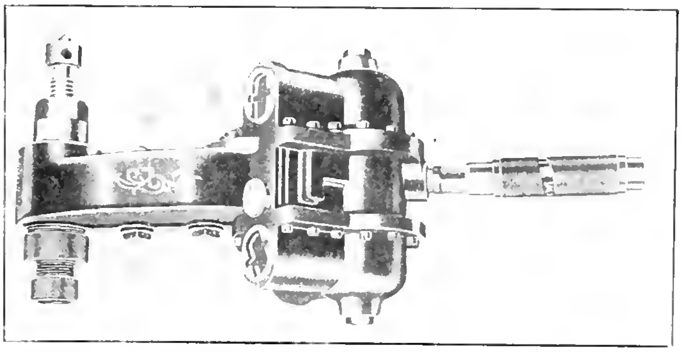
TURBINE STEAMSHIP.—A twin turbine steamer named the "Creole" is being built for the Southern Pacific Company, and will run between New York and New Orleans. This is the first ship of this type to be launched in this country.



DETAILS OF LITTLE GIANT CORNER DRILL.

LITTLE GIANT CORNER DRILL.

The Chicago Pneumatic Tool Company is about to place on the market a "Little Giant" drill designed for drilling in close quarters and especially in corners. It weighs only 35 pounds, and has a capacity for 1½ in. drills, although in an emergency it will drive a 2 in. twist drill with satisfactory results. The spindle speed when running light is 150 r.p.m.; under a load and with 80 lbs. air pressure it operates at 100



r.p.m. The distance from the end of the socket to the end of the screw, when screwed down, is 5⅞ ins.; length of feed 2 ins.; distance from the centre of the spindle to the outside of the housing, 1 5-16 ins.

The accompanying illustrations clearly show the construction of the drill. A steady and uniform spindle movement is insured, due to the use of gears. The various parts of the drill are interchangeable with those of the No. 4 Little Giant drill.

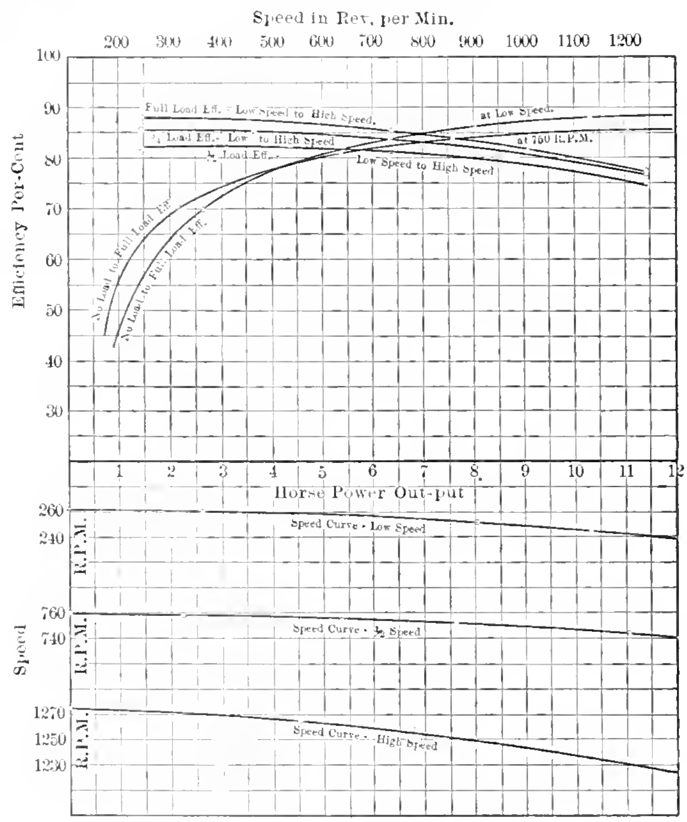
The Average Wages per hour paid in 1905 in 349 occupations in 4,121 establishments were 18.9 per cent. higher than those paid in 1890-99, inclusive, and the average hours of labor per week were 4.1 per cent. lower. The average wages per week in 1905 were 14 per cent. higher than in the same ten-year period, and the total payroll was 52.3 per cent. higher. These figures were recently made public by the U. S. Bureau of Labor, which also states that the retail price of the principal articles of food, weighted according to their consumption in the family, was 12.4 per cent. higher in 1905 than in 1890-99. Therefore the purchasing power on an hour's wages in 1905 was 5.8 per cent. greater than in 1890-99, and of a week's wages 1.4 per cent. greater, the difference between the weekly and hourly figures being due to the reduction of the hours of labor that has taken place lately.—*Engineering Record.*

Higher Salaries in Commercial Lines.—Business firms find it necessary to pay more than the railroads customary $2,500 per year for the man to properly administer a payroll and materials expenditure of $50,000 to $100,000 per month.—*Paul R. Brooks, before the New York Railroad Club.*

THE LINCOLN VARIABLE SPEED MOTOR.

In our July, 1906, issue, page 276, we presented a description of the Lincoln variable speed motor. We have just received an efficiency test of one of these 10 h.p., 5 to 1 motors, which is reproduced herewith.

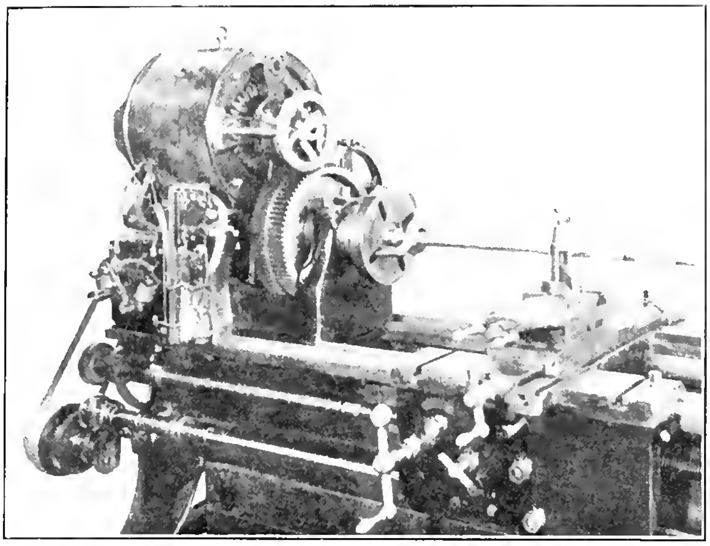
The photograph shows an interesting application of one of these motors to a 22 in. lathe at the American Steel & Wire Company's works, Cleveland, Ohio. The motor is a 3½ h.p., with a speed range of 6 to 1 or 1,800 to 300 r.p.m. It weighs 350 lbs. With the back gears out the lathe has a spindle speed of from 56 to 340 r.p.m., and with the back gears in 9 to 54 r.p.m. The application is neat and compact and the hand wheel, which controls the armature position, thus changing the speed, is placed conveniently for the operator.



TEST OF 10-H.P. LINCOLN VARIABLE SPEED MOTOR.

The following claims are made for the motor: Any speed range within reasonable limits may be furnished, thus making it possible to eliminate trains of gearing and mechanical speed changing devices. No controller or resistance is used, thus eliminating a source of trouble. The horse-power is constant at all speeds. Any speed between maximum and minimum may be obtained at will. Only two direct current wires used—the installation being the same as any ordinary constant speed

motor. For a given horse-power and speed range, the motor is very light in weight and compact in size. It maintains a very steady speed under varying loads. It will stand 50% overload throughout the range without sparking. It will carry



APPLICATION OF LINCOLN MOTOR.

50% overload for one hour without heating above safe limits. It runs equally well in either direction. With it a machine tool can be driven continuously at the highest speed that the tool or work will stand. Its efficiency is high, as shown by accompanying diagram.

RESISTANCE OF WOOD TO SHOCK.—Little study has been given to the resistance of wood to the action of impact loads, such as result when a locomotive passes over a wooden trestle. The Forest Service has been studying the subject at the timber-testing station at Purdue University, Lafayette, Ind., and finds that wood is more elastic under impact than under gradually applied loads. This would go to show the wisdom of locomotive engineers in taking a weakened trestle at high speed. Air-dried loblolly pine specimens, both of natural and steamed wood, 2 by 2 ins. in cross section, were tested in bending on a 34-in. span under both impact and static loadings. The moisture content was approximately 13 per cent. of the dry weight, or about the moisture condition of air-dry wood. The maximum deflection under a gradually applied load was 1.2 ins., and the deflection just preceding failure under impact was 1.1 ins. There is, thus, little difference between the ultimate deflection of wood under the two kinds of loading. But at the elastic limit the average deflection under gradual loading was 0.33 in., while the average deflection under impact loading was 0.66 in. Thus this wood possesses twice the elastic strength under impact that it does under static load.—*From Trade Bulletin 11 of the United States Department of Agriculture, Forest Service.*

KNOW THE REASON WHY.—There is another phase of this case which is perhaps worthy of a moment's notice. Given two young men of equal ability, and let both of them go through good technical schools, both graduating as chemists, or as mining, mechanical, civil or electrical engineers. The one during his course of study has covered much ground, has stored his mind with facts, has learned carefully and well the methods and manipulation required in the branch chosen. The other has not covered so much ground, but every bit of information that he has he thoroughly understands; he has acquired principles rather than a large array of facts, and he knows the reason why. Let now these two begin work after graduation in the same place, and we are ready to confess that the former will make the best showing, and progress the more rapidly for the first year or two, but if our observation is worth anything, the latter will distance his competitor at the end of ten years.—*Dr. Chas. B. Dudley.*

FASTEST LONG DISTANCE RUN.

In a letter to the *Railway Age*, Mr. D. C. Moon, assistant general manager of the Lake Shore & Michigan Southern Railway, gives the first authorized account of a very high speed run made on the Lake Shore & Michigan Southern Railway on June 13, 1905, between LaSalle Street Station, Chicago and Exchange Street Depot, Buffalo. The distance is 525 miles and the train, which consisted of a coach and two private cars, made it in 7 hours and 33 minutes, or 453 minutes total elapsed time. Outside of slow running through yards and two grade crossing stops there was a total of 9 minutes lost in changing engines at four different points. This time was the actual time that the train was standing still and does not include any correction for the time lost in slowing down and starting again, hence the total time in which the train was moving, including also the two grade crossing stops, was 444 minutes for the 525 miles, or an average rate of speed of 70.94 miles per hour. The speed including the time for stops was an average of 69.53 miles per hour.

No special arrangements were made in advance for this run except to provide for the dispatchers to see that the way was clear. The speed was noted by a stop watch for many individual miles during the run and it was found that many of them varied from 41 to 45 seconds per mile and the fastest mile noted was 40 seconds or at the rate of 90 miles per hour. Aboard the train at the time, in addition to others, were Mr W. H. Marshall, then general manager of the railroad, Mr. E. A. Handy, then assistant general manager, and Mr. D. C. Moon, then assistant general superintendent. This undoubtedly is the record for speed of railway trains for this distance and its accuracy is without question.

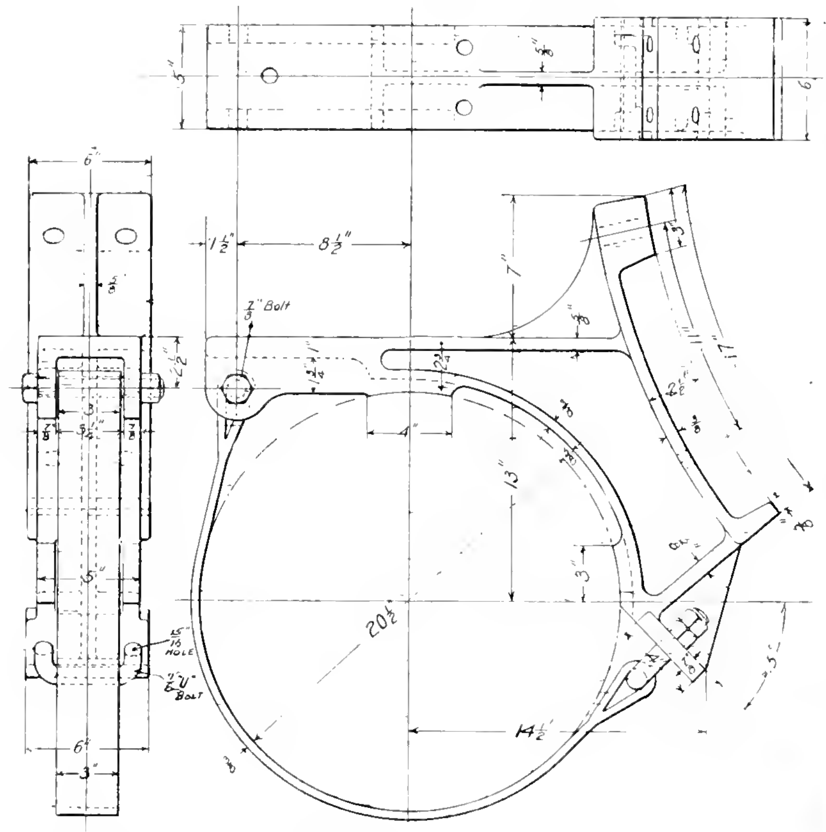
STEAM AUTO-CARS IN ENGLAND.—The North-Eastern Railway Company has greatly extended the employment of steam railway auto-cars, which give a speedier and more economical service than is possible with the ordinary steam driven trains. The auto-cars consist of a light tank passenger engine coupled to a bogie carriage of the company's standard pattern, so altered as to accommodate 50 third-class and eight first-class passengers, with a luggage compartment and driver's compartment. These cars may be operated either from the locomotive or from the driver's compartment at the end of the car by means of suitable gearing and levers, enabling it to be controlled in either direction without turning. The engine cylinders have been reduced so that the lighter load taken may be worked correspondingly cheaper, this alteration having been carried out at the Darlington works. Nineteen of these coaches are now in actual service, but the total stock will be 29 engines and 28 cars. The auto-cars are in service over practically every branch line between the Humber and the Tweed.

HIGH SPEED STEEL AND FINISHING CUTS.—Doubts have arisen at times as to whether high-speed steel would take finishing cuts. In the early stages of its manufacture, such contentions were somewhat justifiable, but with the knowledge gained from its use, together with greater experience and knowledge of its manufacture, the early difficulties have been largely overcome. The writer wishes it to be understood that he does not state that rapid cutting steel will produce a high finish under all conditions, for with certain metals a special carbon alloy steel—suitable for hardening in water, will give greater satisfaction, but on the other hand, there are very many operations where high-speed steel will produce the desired finish, and by reason of greater endurance, continue to work for very much longer periods than water hardening steels, and in such cases there can be no doubt of its advantage for this work. In fact, many instances could be quoted where ordinary steel has failed and been successfully replaced with high-speed steel.—*J. M. Gledhill.*

RUNNING BOARD BRACKET AND AIR RESERVOIR SUPPORT.

A new design of cast steel running-board bracket and air reservoir support is being applied by the American Locomotive Company to some of the recent locomotives built by them. The illustration shows the design as applied to the Mogul locomotives for the Vandalia Line, which are illustrated elsewhere in this issue.

As can be seen in the illustration, this consists of a cast steel bracket fastened to the boiler by four ⅞-in. studs and forming a bearing for the top and inner side of a 20½-in. air



AIR DRUM SUPPORT AND RUNNING BOARD BRACKET—AMERICAN LOCOMOTIVE C

reservoir, which is held in place by ⅜ x 3-in. straps. The strap at each bracket is constructed with an eye passing over a ⅞-in. bolt at the outer end of the cast steel bracket and connecting to a ⅞-in. U bolt at the lower end. This U bolt is threaded for a sufficient distance to allow the strap to be drawn up tightly and hold the drum securely in place. By this method the top of the running-board bracket is left entirely clear, and there are no projections extending up through the running-board, as is usually the case with air-drum supports. The illustration will make clear the features of the design.

AUTOMATIC ELECTRIC MOTOR DRIVEN PUMPING STATION.

The ease of adapting automatic methods of control to the electric motor makes it most convenient for driving pumping machinery. It is generally a simple matter to arrange a float operated switch to open and close the motor circuit so that the expense of an attendant, necessary with a steam plant, is eliminated, and the pumping set can be erected advantageously in an isolated position. This is especially true along railway lines where, if electric current is available, an automatic electric pumping set may be installed to fill the water supply tanks for the locomotives.

A very successful induction motor driven pumping plant for this purpose is in operation on the lines of the Lake Shore & Michigan Southern Railway at South Bend, Indiana. The pumping outfit consists of two Worthington single-stage turbine pumps, each direct connected to a six-pole, 7½ horsepower, three-phase, 440 volt General Electric Company's induction motor. Two pumping sets are installed, so that in case one set fails, repairs can be made without shutting down the plant. Power for operating the motors is taken from the lines of the St. Joseph and Elkhart Power Company.

In Fig. 1 is shown a view of the pumping house. This is a

FIG. 1—ELECTRIC PUMPING STATION.

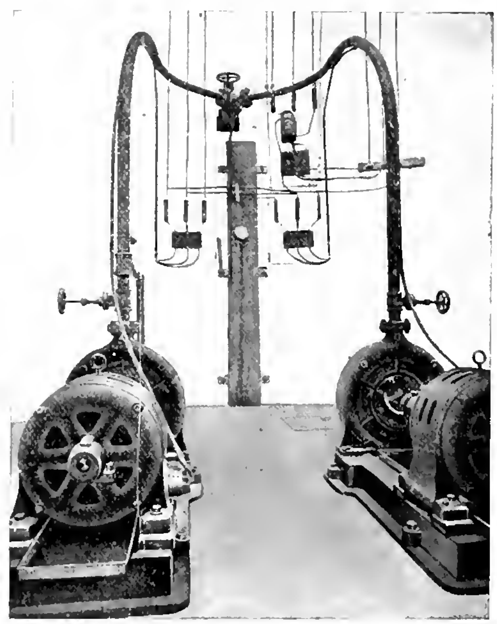


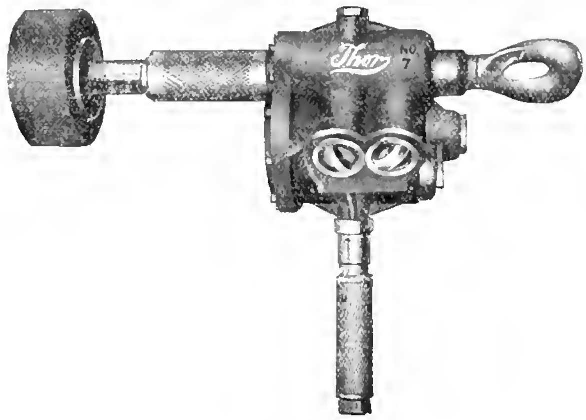
FIG. 2—INTERIOR OF ELECTRIC PUMPING STATION.

round brick structure erected at the top of a concrete lined well. The floor is of concrete, supported by I beams, and is ten feet below the level of the ground. Upon this the pumps are erected, the interior arrangement being shown in Fig. 2. For keeping the pump room dry four ventilating ducts are built into the wall of the pump house, the outlets appearing in the pilasters in Fig. 1.

Each pump discharges water through a 2½-inch pipe connecting with a 4-inch main, which leads to the supply tank. This tank is located at the side of the tracks, about 100 feet from the pumping station. The controlling device is arranged in the housing on the roof, the motors being started and stopped automatically by a small oil-switch operated by a float, which has a vertical movement of about one foot. This difference in level in the tank corresponds to 3,000 gallons of water. This is the average amount taken by a locomotive, and is replenished by the pumping set in about twenty-five minutes. The supply tank holds about 50,000 gallons, and could supply fifteen locomotives within a few minutes if necessary. However, such a heavy demand will probably never be made, and in actual practice the pumps stand idle for the greater part of the time.

PNEUMATIC GRINDING MACHINE.

A new portable pneumatic grinding and burnishing machine is being manufactured by the Independent Pneumatic Tool



THOR PNEUMATIC GRINDING MACHINE.

Company, Chicago, which apparently fills all the requirements for a machine of that nature. It has a speed of 3,000 revolutions per minute, weighs but 20 pounds and consumes but 20 cubic feet of free air per minute.

The motor is of the reciprocating piston type, having four pistons, direct-acting on the crank, and is equipped with a special Corliss type of valve motion, which gives it a surprisingly large amount of power.

The grinding spindle proper is held in the housing extended from the end of the motor in line with the crank shaft. It is not a part of the crank shaft, however, but is connected with it. The grinding spindle itself runs on a combination of ball and plane bearings. There is a large bronze bearing at the inner end, and then a four-point ball bearing, which acts as a thrust bearing both ways, and also as a support for the shaft. At the outer end is a metallic packing that also acts as a bearing, and at the same time prevents the lubricating oil from running out of the machine. The motor and shaft run in a bath of oil.

A grip handle is placed in line with the grinding spindle, and the outside of the housing of spindle will also serve as a handle. Mandrels of any suitable length or shape may be attached to the grinding spindle for driving emery wheels, soft polishing wheels, or discs.

This machine is designated as The Thor Pneumatic Grinder No. 7.

CASE HARDENING.—A new German process of case hardening is claimed to give results superior to any hitherto obtained. It is said that a piece weighing 400 pounds can be hardened 0.040 inch deep, and so hard that no steel will cut it, though it may be welded. The work to be hardened is heated in bone dust powder to which is added ¾ pound of yellow prussiate, ½ pound of cyanide of potasium, and one pound of phosphorus. It is heated to a very high temperature in a closed box.—*Machinery.*

PERSONALS.

Mr. George M. Basford has been appointed assistant to the president of the American Locomotive Company.

Mr. J. H. Green has been appointed master mechanic of the Norfolk & Southern R. R., with headquarters at New Bern, N. C.

Mr. N. N. Boyden, master mechanic of the Southern Railway at Selma, Ala., has been transferred to Birmingham in the same capacity.

Mr. F. M. Steele has been appointed road foreman of engines of the New York Central & Hudson River R. R. at Rochester, N. Y.

Mr. F. P. Roesch, master mechanic of the Southern Railway at Birmingham, Ala., has been transferred to Spencer, N. C., in the same capacity.

Mr. J. S. Coniff has been promoted to the position of road foreman of engines of the east end of the Cumberland division of the Baltimore & Ohio R. R.

Mr. Herbert Riddle has been appointed roundhouse foreman of the Denver & Rio Grande R. R. at Salida, Colo., succeeding Mr. W. C. Chambers, resigned.

Mr. A. L. Schilling has been appointed foreman of the boiler shop of the Colorado Midland Railway at Colorado City, vice Mr. Charles Zeitz, resigned.

Mr. William Miller has been appointed acting superintendent of motive power of the Denver & Rio Grande Railroad, vice Mr. J. R. Groves, resigned.

Mr. P. H. Cosgrave has been appointed general foreman of the car department of the Colorado Midland Railway, with office at Colorado City, Colo.

Mr. W. G. Edmondson, engineer of tests, has been appointed mechanical engineer of the Philadelphia & Reading Ry., succeeding F. F. Gaines, resigned.

Mr. J. H. Dummer has been appointed foreman of the machine shops of the Colorado Midland Railway at Colorado City, Colo.

Mr. D. Anderson has been appointed master mechanic of the Chicago Union Transfer Railway, with office at Clearing, Ill., in place of Mr. E. Owen, resigned.

Mr. W. C. Whittaker has resigned as general foreman of the Colorado City shops of the Colorado Midland Railway, and the office has been abolished.

Mr. T. R. Shanks has been appointed master mechanic of the East Board Top Railroad, with office at Orbisonia, Pa. vice Mr. Edgar Shellabarger, deceased.

Mr. J. J. Dewey, master mechanic of the Cincinnati division of the Erie Railroad, has been transferred to the New York division, with office at Jersey City, N. J.

Mr. C. James, master mechanic of the Rochester division of the Erie Railroad, has been appointed master mechanic of the Erie division, with office at Galion, Ohio.

Mr. D. Van Riper, general foreman of the Meadville shops of the Erie Railroad, has been appointed master mechanic of the Rochester division, with office at Avon, N. Y.

Mr. F. W. Williams has been appointed master mechanic of the Oklahoma division of the Chicago, Rock Island & Pacific Ry., vice Mr. James McDonough, resigned.

Mr. B. G. Miller, general car foreman of the Atchison, Topeka & Santa Fe Railway at Cleburne, Tex., has resigned to become general car foreman of the El Paso & Southwestern.

Mr. R. Griffith has been appointed master mechanic of the Colorado Midland Railway Company at Colorado City, Colo. The office of superintendent of machinery has been abolished.

Mr. Q. A. Moriarity, general foreman of the Port Jervis shops of the Erie Railroad, has been appointed master mechanic of the Delaware division, with office at Port Jervis.

Mr. George Akans has been appointed master mechanic of the Southern Railway at Selma, Ala.

Mr. Howard Stillman, heretofore engineer of tests of the Southern Pacific Ry., has been appointed mechanical engineer succeeding F. W. Mahl, resigned.

Mr. William Schlafge, master mechanic of the New York division of the Erie Railroad, has been appointed master car builder at Meadville, Pa., succeeding Mr. R. W. Burnett, resigned.

Mr. O. A. Fisher, master mechanic of the Atchison Topeka & Santa Fe Railroad at Chanute, Kan., has been transferred to La Junta, Colo., in a similar capacity, succeeding Mr. R. Smith, resigned.

Mr. F. F. Gaines, heretofore mechanical engineer of the Philadelphia & Reading Railway, has been appointed to the new office of superintendent of motive power of the Central of Georgia Railway.

Mr. W. S. Murrian, master mechanic of the Southern Railroad at Spencer, N. C., has been appointed superintendent of motive power of the middle and western districts, with headquarters at Knoxville, Tenn.

Mr. W. J. Crandall has been promoted to the position of master mechanic of the New York Central & Hudson River R. R. at Syracuse, N. Y., having charge of the territory between Rochester and Syracuse.

Mr. A. Stewart has been appointed general superintendent of motive power and equipment of the Southern Railway, with headquarters at Washington, D. C. The office of mechanical superintendent has been abolished.

Mr. W. A. Tribby has been appointed fuel inspector of the Baltimore & Ohio R. R. and will look after the fuel used on locomotives over the entire system exclusive of the Baltimore & Ohio Southwestern. He will report to Mr. Muhlfeld.

Mr. James Hainen, general master mechanic of the Southern Railway at Greensboro, N. C., has been appointed superintendent of motive power of the northern and eastern districts of the Southern Railway, with office at Greensboro.

Mr. C W. Seddon, superintendent of shops of the Great Northern Railway at Duluth, Minn, has been appointed superintendent of motive power and cars of the Duluth, Missabe & Northern Railway, with headquarters at Proctor, Minn.

Mr. J. A. MacNeill has been appointed chief inspector of the Union Pacific R. R., with office at Omaha, Neb., vice Mr. F. Jerdone, Jr, resigned. He will have charge of inspection of passenger and freight cars, locomotives and all materials entering into their construction. Mr. MacNeill was formerly connected with the Atchison, Topeka & Santa Fe Railway in the inspection department.

Mr. John R. Blakeslee, president of the Ajax Manufacturing Company, Cleveland, Ohio, died November 9 of Bright's disease, aged 63 years. He was born in Winsted, Conn. At the outbreak of the Civil War he enlisted in the Union Army and at the close of the war located for a short time at Indianapolis, after which he went to Youngstown, Ohio, and then to Cleveland, where he engaged in the machinery business, shortly afterward founding the Ajax Manufacturing Company.

Mr. Henry W. Jacobs has been appointed assistant superintendent of motive power of the Atchison, Topeka & Santa Fe Railway. As noted in the article on "Betterment Work on the Santa Fe" in our last issue Mr. Jacobs has had charge of the tool and machinery betterments for the entire system, and has had direct charge of all the betterment work on the Coast Lines. The significance of Mr. Jacobs' appointment is considered editorially on another page of this issue. He was born in 1874, and from 1888 to 1894 was with the Seaton Foundry Company, Atchison, Kansas, as apprentice, machinist, moulder and structural iron worker. Since that time his experience has been as follows: Machinist with the U. S. Gun Shop, Washington, D. C.; marine experience with U. S. Government, testing engines, trial runs, etc.; machine and erecting machinist, with the Sprague Electric Company, R. Hoe and Company, and Crocker & Wheeler; 1899, manager, Vulcan Engineering Company, engaged in repairs and building of stationary and marine machinery; 1900, took up railway work as erecting machinist, K. C. S. J. & C. B. Ry; tool-room foreman, Burlington Railroad; general shop demonstrator, Union Pacific Railroad.

BOOKS.

Immediate Care of the Injured. By Albert S. S. Morrill, M.D. 340 pages. Published by the W. B. Saunders Co., Philadelphia. Price $2.50.

This volume is intended to be useful alike to physicians, nurses and laymen, as well as to serve as a text book for the use of first aid classes. The subject has been presented in as simple language as possible, technical terms being omitted. It is profusely illustrated by both photographs and drawings.

Switchboards. By William Baxter, Jr. 5½ by 8 in., 188 pages. Cloth. Illustrated. Published by the Derry-Collard Company, New York. Price $1.50.

This book discusses the construction, arrangement and wiring of practically all types and sizes of switchboards. It is profusely illustrated with half tones and line drawings. A special section of the book is given up to the subject of switches, which includes circuit breakers, lightning arresters, etc. The matter included covers both direct and alternating current for power, lighting or railway service.

Combustion and Smokeless Furnaces. By Joseph W. Hayes. 6½ by 9½ ins. Cloth. Illustrated. Published by The Hill Publishing Company, 505 Pearl St., New York. Price $1.50.

This book is written for the purpose of putting the owners and engineers of power plants in possession of information so that they may deal intelligently with the smoke abatement problem. The matter throughout is presented in a popular way with no mathematical or chemical symbols beyond the comprehension of the average reader and appears to effectively fulfil the purpose for which it is written.

Proceedings of the National Railroad Master Blacksmiths' Association. Fourteenth Annual Convention, Chicago, 1906. Edited by A. L. Woodworth, Lima, O.

This volume contains the complete reports of committees and individual papers together with the discussion thereon, delivered at the last annual convention. These included committee reports on frogs and crossings, flue welding, classification of work in the shop, annealing and tempering high speed steel, case hardening, piece work, and making of locomotive frames, as well as individual papers on, formulæ for rings; tools and formers for bulldozers; shop discipline; best coal and kind of fires and thermit. A list of the members, standing committees and subjects for next year are also included.

The Walschaert Locomotive Valve Gear. By W. W. Wood. 5 by 7½, cloth, 185 pages, illustrated. Published by the Norman W. Henley Publishing Company, 132 Nassau St., New York. Price, $1.50.

This, so far as we know, is the first book in English which is devoted exclusively to the Walschaert valve gear, and it fills a demand which during the last few months has become very insistent. It is written in a simple, straightforward style, and the mathematical analyses are elementary. The points in discussion are clearly illustrated by numerous plates, both in half-tone and line drawings; two large folding plates that show the position of the valves of both inside or outside admission type, as well as the links and other parts of the gear when the crank is at nine different points in its revolution are especially valuable in making the movement clear. These employ sliding cardboard models, which are contained in a pocket in the cover. The book is divided into four general divisions, as follows: I. Analysis of the gear; II. Designing and erecting the gear; III. Advantages of this gear; IV. Questions and answers relating to the Walschaert valve gear.

The last division contains sixty pertinent questions with full answers on all the features of this type of valve gear, which will be especially valuable to firemen and engineers in preparing for an examination for promotion.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

Air Compressors.—The Ingersoll Rand Company, New York, is issuing a catalog, which illustrates and describes in detail the Imperial type 10 air compressors. These compressors are furnished in both steam and power driven types and contain many refinements of details which are clearly illustrated and described in this catalog.

Automatic Vises.—The Pittsburg Automatic Vise and Tool Company is issuing a small pamphlet which illustrates and briefly points out the special features of different types of automatic double and single swivel vises. These vises are automatic in that the tightening of the jaws upon the piece automatically locks all of the swivels. They are shown in designs which cover practically every conceivable demand.

Electric Locomotives.—The General Electric Company is issuing a paper bound catalog on the subject of electric mine locomotives in which the general structure and many details of several designs of electric mine locomotives recently built are illustrated and carefully described. These locomotives can be obtained in practically any arrangement and pulling capacity. The illustrations show a large number of interesting types at work.

Inter-Pole Motors.—The Electro-Dynamic Company, 11 Pine street, New York, are sending out three bulletins, one presents the revised ratings and diagrams of these motors; another contains a reprint of a paper on "Direct Current Motor Design as Influenced by the Use of the Inter-Pole," presented by C. H. Bedell before the American Institute of Electrical Engineers; the third contains reproductions of several letters from users of the Inter-Pole motors.

Air Compressor Lubrication.—The Joseph Dixon Crucible Company is issuing a pamphlet with the above title, which very thoroughly considers this important subject. The danger of causing an explosion in the cylinders, pipes, or receivers of air compressors when the temperature of compression exceeds the flashing point of the lubricant used is becoming generally recognized. This pamphlet considers the subject and its remedies, showing wherein flake graphite is of value, not only from the standpoint of safety but also of economy.

Hunt-Spiller Iron.—The Hunt-Spiller Manufacturing Corporation, 383 Dorchester avenue, South Boston, Mass., is issuing a pamphlet which illustrates a small portion of its works and a few of the various castings being made. This iron is of a special quality and tests have shown it to possess a tensile strength of 35,000 lbs. per sq. in. It is very close grained and is said to have exceedingly fine wearing qualities, which makes it particularly desirable for locomotive work. The illustrations show castings for wheel centres, driving boxes, eccentrics and straps, pistons, cylinders, cylinder heads, bushings, etc.

What We Do.—The Wellman-Seaver-Morgan Company is issuing a pamphlet entitled "What We Do In Iron and Steel Works Equipment, Ore and Coal Handling Machinery, Cranes, Etc.," which briefly mentions the many and diversified kinds of work which this company is prepared to undertake. Illustrations are included showing some of the more important pieces of equipment which have recently been finished. This company is prepared to design and equip complete plants of any type, taking a bulk contract for the work. They also design and build special machinery of practically all kinds.

Universal Tool Grinder.—Those interested in the grinding and maintenance of lathe and planer tools should make a point of securing this catalog, describing the Gisholt universal tool grinder, published by the Gisholt Machine Company, Madison, Wis. The catalog is a typical Gisholt publication — handsomely illustrated and printed. The first few pages are devoted to a consideration of the matter of eliminating wastes, due to the improvement of tool grinding and maintainance. The remaining part considers the Gisholt system of tool grinding, the correct method of forging the tools and a description of the Gisholt grinder.

Fort Wayne Electric Works.—This company is issuing a number of bulletins, arranged for binding in a loose leaf binder, which are numbered from 1,082 to 1,085 inclusive. These each illustrate and describe a single apparatus and are on the following subjects: Mutiple alternating current street arc lighting system; type M A and M induction motors; standard switchboard panels for multi-phase generators, and integrating switchboard watt meters.

Hawthorne Works.—This very attractive pamphlet illustrates and briefly describes the Hawthorne plant of the Western Electric Company which has recently been completed and will be used for the manufacture of heavy power apparatus and switchboards. An interesting part of the description is that devoted to the provisions against the interruption of the work or shutting down of the plant. These include a system of coal storage providing sufficient coal to operate the plant for four months under normal winter condition, and an elaborate system of fire protection and water supply. Some interesting applications of individual motors to machine tools are shown in connection with interior views of the machine shop. The description of the power plant and electrical equipment is also of special interest.

Annealing, Brazing and Melting Furnaces.—The Rockwell Engineering Company, 26 Cortlandt Street, New York, is issuing a number of new catalogs descriptive of its products. One of these is a leaflet on the Rockwell annealing and hardening furnaces, using oil or gas fuel. Another is on the Rockwell heating machines for annealing, hardening, tempering or coloring quantities of like pieces of gold, silver, bronze, copper, steel, etc. The third one is a leaflet on the Rockwell brazing furnaces, which are made in several different designs and sizes. Another considers the Rockwell double chamber metal melting furnace, which is arranged so that the two chambers are used alternately and the exhaust heat from the active chamber flows into the other. Another catalog illustrates and describes several types of fuel oil burning appliances and accessories.

Progress Reporter.—The December issue of the "Progress Reporter" of the Niles-Bement-Pond Company consists of 48 pages, practically all of which are given up to full page illustrations of the machines in use in the machine shops of the Midvale Steel Company. In these shops some of the most interesting work in the country is done, both in regard to the size of the pieces handled as well as to the extreme accuracy necessary. This company does much work for the government in connection with armor plate, guns of all calibres, marine engines, steel castings, etc. The illustrations in this number of the "Reporter" show the machines furnished by the Niles-Bement-Pond Company in operation on many of these very interesting pieces of work. Notable among these might be mentioned a 12 ft. pit planer, which weighs over 500,000 lbs., and will finish the four edges and one face of an armor plate 24 ft. long, 12 ft. wide and 1 ft. thick.

Power Transmitting Machinery.—The George V. Cresson Company, engineers, founders and machinists, of New York and Philadelphia, is issuing a 350 page, cloth bound, 6 x 9½ in. catalog, which is known as "Catalog B" and supersedes all previous issues. This book, in addition to being a most complete and interesting catalog of the products of this company, is also filled with valuable and reliable data on power transmission equipment. Many engineering rules, formulas, and reference tables have been included. The unusually good illustrations of each article are accompanied in every case by listed tables giving the sizes in stock and prices at which each can be obtained. These tables are numbered in heavy bold face type and the complete index at the end of the book permits any desired number being quickly found. A noticeable feature in the catalog is the fact that each separate type or design is shown separately, having its own individual size and price list. The sizes are made comprehensive by means of line drawings with lettered dimensions. This company handles steel shafts of all kinds, shaft collars, flange couplings, clamp couplings, jaw clutches, flexible couplings, shaft bearings and hangers, girder clamps, pillow blocks, pulleys of all descriptions, fly wheels, gear wheels, belt tighteners, crushers, separators, and in fact every appliance connected with power transmitting machinery. The illustrations are from retouched photographs and are printed in tints of two colors. The artistic work in both illustrations and general arrangement of the book is exceptionally good and it will be found to be not only a valuable reference work but also a fitting addition to any book shelf.

WOOD WORKING MACHINERY.—A 300 page catalog, "B," issued by the "Oliver" Machinery Company, Grand Rapids, Mich., describes in detail their complete line of wood working machinery and supplies. A well arranged index adds greatly to its value as a reference book. In many instances line drawings are introduced in addition to the half tone illustrations in order to make the construction of machine or tool more clear.

EXAMPLES OF RAPID MILLING.—This is a 64 page, handsomely illustrated publication issued by the Cincinnati Milling Machine Company as a supplement to their milling machine catalog. It contains 60 illustrations, showing a great variety of work done on their plain milling machine, each of which is accompanied by data as to the work, the cutters, the size of the cuts and the rate of doing the work. Very valuable to those interested in this class of work.

NOTES.

ELECTRIC CONTROLLER AND SUPPLY COMPANY.—This company is sending to its friends a copy of the painting, "Laurie," done in black and white embossed work.

DAYTON PNEUMATIC TOOL COMPANY.—Mr. L. A. Wyman has accepted a position in the sales department of the Dayton Pneumatic Tool Company, with headquarters at Dayton, O.

ADREON & COMPANY.—This company announces that it has established an office at No. 208 Western Union Building, Chicago, which is in charge of Mr. Edwin W. Hodgkins, vice-president of the company.

CANADIAN FAIRBANKS COMPANY, LTD.—Mr. William S. Howe has resigned his position with the S. A. Woods Machine Company after eleven years service, and in January will become connected with the Canadian Fairbanks Company, of Montreal, Winnipeg, Toronto and Vancouver.

NILES-BEMENT-POND COMPANY.—The directors of this company have declared a stock dividend of 40 per cent. on the $5,000,000 outstanding common stock, payable January 2 to holders of record on November 30. Of the $3,500,000 additional common stock recently authorized $2,000,000 is to be issued as the above dividend, and the rest is to be sold to present stockholders. It is also reported that the Ridgeway Machine Tool Company, of Ridgeway, Pa., has passed into the control of this company.

THE B. F. STURTEVANT COMPANY.—This company is installing a complete equipment of the blower system of heating and ventilating in an eighteen-stall roundhouse of the Canadian Pacific Railway, located at Broadview, Sask. The same company is also installing similar outfits in the new car barn of the Philadelphia & Western Railway, at Llanerchy, Pa., which contains over 600,000 cu. ft. of space, and in the car repair shops of the Somerset Railway Co., Oakland, Me.

ELECTRICAL APPARATUS AT THE COLLINWOOD SHOPS.—The electrical apparatus at the Collinwood shops of the Lake Shore & Michigan Southern Railway was described in a series of articles in this journal during the year 1903. A new 300 k. w., 250 volt Crocker-Wheeler generator has recently been added to this equipment. It operates at 150 r.p.m., has 10 poles, and a 13½ in. commutator face. The full load current is 1,200 amperes, the range from no load to full load being free from sparking without adjusting the brushes, and even momentary overloads as high as 75 per cent. are possible without injurious sparking.

The Crocker-Wheeler Ward-Leonard multiple voltage system of speed control is used. This was one of the first shops to use individual motor driven machine tools, about three-eighths of the tools first installed being individually driven by Crocker-Wheeler motors. That the experiment has proved successful is indicated by the fact that a very large percentage of the machines are now driven in this way.

GENERAL ELECTRIC COMPANY.—This company has made a contract with the Texas Traction Company for the equipment of a 65-mile electric railroad between Dallas and Sherman, Texas. This line will parallel the existing steam line between the two cities and will be one of the longest electric roads in the state. Power will be generated at McKinney, a town about midway on the line. The equipment of the power station includes two 1,000 k.w. Curtis steam turbo-generators. The current will be generated at 2,200 volts and 25 cycles, and stepped up to 19,100 volts for transmission. The three-phase current from each of the generators will be transformed in a set of three 330 k. w. air blast transformers. Six sub-stations will be provided, including one at the main power house and a portable equipment, the latter comprising a special car containing 300 k. w. rotary converters, air blast transformers and suitable switching apparatus for cutting into the transmission system wherever necessary. The permanent substations have similar equipment delivering 600 volts direct current to the line. It is expected that the transmission potential will eventually be at 33,000 volts, and taps will be provided on the transformers with this in view. The rolling equipment and other features follow in general the standard direct current practice of the General Electric Company.

EXTENSION TO THE WEST ALLIS WORKS OF THE ALLIS-CHALMERS COMPANY.—The extensions to the West Allis, Milwaukee Works of the Allis-Chalmers Company, which are now approaching completion, will add 861,000 sq. ft. to the plant's present floor area of 652,000 sq. ft., and make the entire plant capable of affording employment to 11,000 persons. This in connection with the other plants of this company will give it facilities for affording employment to a total of 18,000 persons. The extensions being built consist of three machine shops running east and west and parallel to the existing units of which there are three. These new units will be 575 ft. long and two of them 145 ft. wide, while the third is 168 ft. wide. The new erecting shop will run north and south as an extension to the present shop and will be 1,136 ft. by 113 ft. in size. An extension is also being made to the present foundry, which will give it a total length of 994 ft. and a width of 222 ft. Also an extension to the pattern building, which will give it a length of 994 ft. and a width of 119 ft. The work of constructing these extensions involves an expenditure of over three million dollars.

Machine shop No. 4, which is typical of all six units, is constructed to form two principle bays in cross section, the one on the south side of the building being 66 ft. wide and 52 ft. high, and is served by a 50 ton crane. The bay on the north side is 71 ft. wide and 42 ft. high, and has a line of intermediate columns dividing it into two divisions, one of which is 40 ft. wide and is served by a 10 ton crane. A gallery floor covers the north bay and a mezzanine floor for lavatories, coat rooms, etc., is suspended from the gallery floor girders. Three elevators, of the plunger type, are installed for service to the mezzanine floor and gallery. Tracks extend from the south bay running east and west into the erecting shop. Machine shop No. 6 differs from the others in several features, being four stories in height and built around a central court. The two principle four story bays are 53 ft. wide and 72 ft. high, and are connected at both ends by bays of similar height for a width of 32 ft. at one end and 16 ft. at the other. The centre section is roofed over to a height of one story and divided into two bays, each 26 ft. wide. The erecting shop is practically a duplication of the present building in construction, the principle bay being 72 ft. wide and 72 ft. high and served by a 75 ton crane with a 60 ft. lift. The new foundry and pattern buildings are of the same construction as the existing buildings, being of the modern type adapted to these purposes.

The power house equipment, for furnishing power to the works' extensions consists of one 34 and 54 x 42 in. Reynolds vertical cross compound engine, direct connected to a 1,000 k. w. Bullock direct current generator and an Allis-Chalmers cross compound air compressor with air cylinders 18 and 30 x 42 ins., the steam cylinders being of the same size. In the boiler house five Edgemoore tube boilers with a total aggregate horse power of 3,293, and a heating surface of 6,586 sq. ft. each, will replace the present boiler equipment. The new boilers will be operated in connection with Jones under feed stokers. A stack 175 ft. high and 8 ft. inside diameter will furnish natural draft.

The heavy machine tools of various kinds at present installed will be duplicated in the new machine shop units and supplemented by special tools suitable for specific purposes, such as the building of steam turbines, gas engines, etc. Direct current at 250 volts is distributed throughout the works for the operation of motors on machine tools. These motors are largely operated on the Ward-Leonard multiple voltage five-wire system which gives 27 different speeds for each motor. The yards between the various buildings are as completely equipped with cranes as is the interior of the building, and are utilized for storage.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

FEBRUARY, 1907.

STEEL PASSENGER CAR.

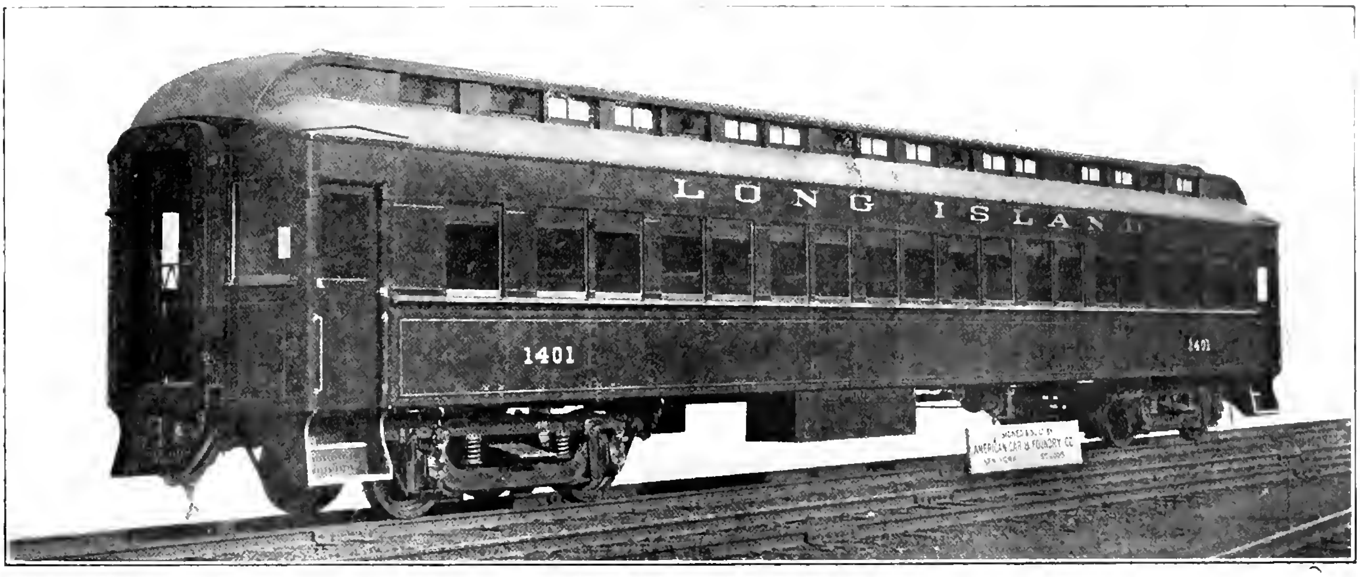
LONG ISLAND RAILROAD.

The American Car & Foundry Company has recently designed and built a sample all-steel passenger coach for the Long Island Railroad. This car is constructed to give the same floor plan as the present Pennsylvania standard passenger car, and will seat 72 persons. It is practically all steel throughout, the only wood found in the construction being a small amount used for holding a part of the interior finish. Its length over buffers is 67 ft. 4¼ ins., and its total weight in running order is 94,500 lbs.

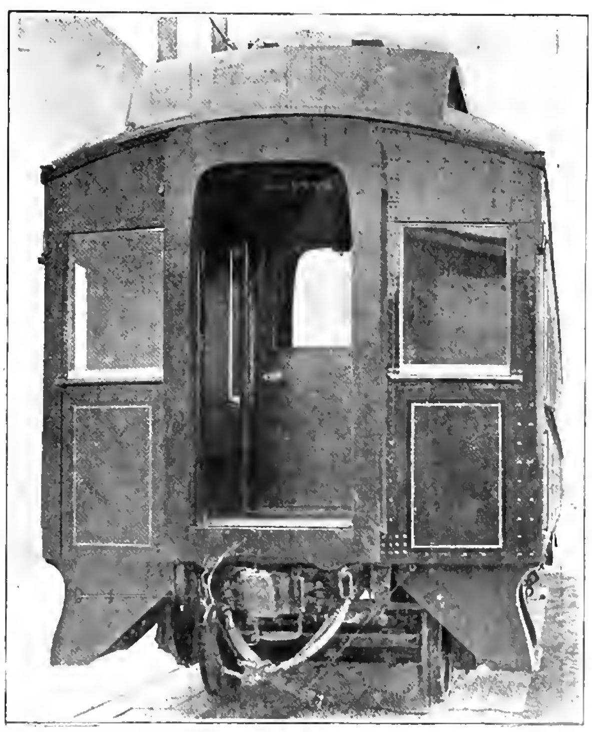
The primary considerations in designing this car were: First, to make it absolutely fireproof; second, to so arrange the construction as to make it as strong, or stronger in collision, than any passenger car now running, and, third, to make it as light in weight as the other considerations would permit. Special care was also given to making both the exterior and interior of as pleasing an appearance as possible. That all of these problems have been successfully solved is evident from a careful inspection of the illustrations shown herewith. It is evidently fireproof, as there is nothing combustible in its construction. To withstand ordinary buffing strains and shocks due to collisions, the car is equipped with Westinghouse friction draft gear and the Gould friction buffer, which have a combined capacity of something over 300,000 lbs.; and the center sills, consisting of 10-in. I beams which are continuous from buffing beam to buffing beam; and the platform I beams extending from the buffing beam through both members of the double bolster and tied together by ¼-in. steel plates riveted to the top flanges and used as platform floor plates. In addition to these the diaphragms are so arranged that the side girders of the car will also assist the center sills to withstand any shocks. Furthermore, from a study of the design it will be seen that the vestibule and roof construction are such as to prevent a collapse of the body in case of a corner blow or of overturning upon an embankment. The design of the hood is such that should it become distorted by reason of a collision it can be removed without disturbing the main members of the body framing. By reference to the drawings it will be seen that the body end carline is double and the purlines and rafters are not continuous, the two angle irons forming the body end carlines being held together by rivets passing through spacing thimbles, the eaves angles and side plate angles being the only continuous members connecting hood to body framing.

In the matter of weights it is interesting to note that this car weighs, exclusive of the storage batteries, but 1,233 lbs. per seated passenger, while one of the modern wooden coaches on the P. R. R., which does not carry storage batteries, weighs 1,363 lbs. per seated passenger. That car is 5 ft. 3¼ ins. shorter than the Long Island car and seats but 62 persons. The excellent appearance of both the exterior and interior of the car is shown in the reproductions from photographs.

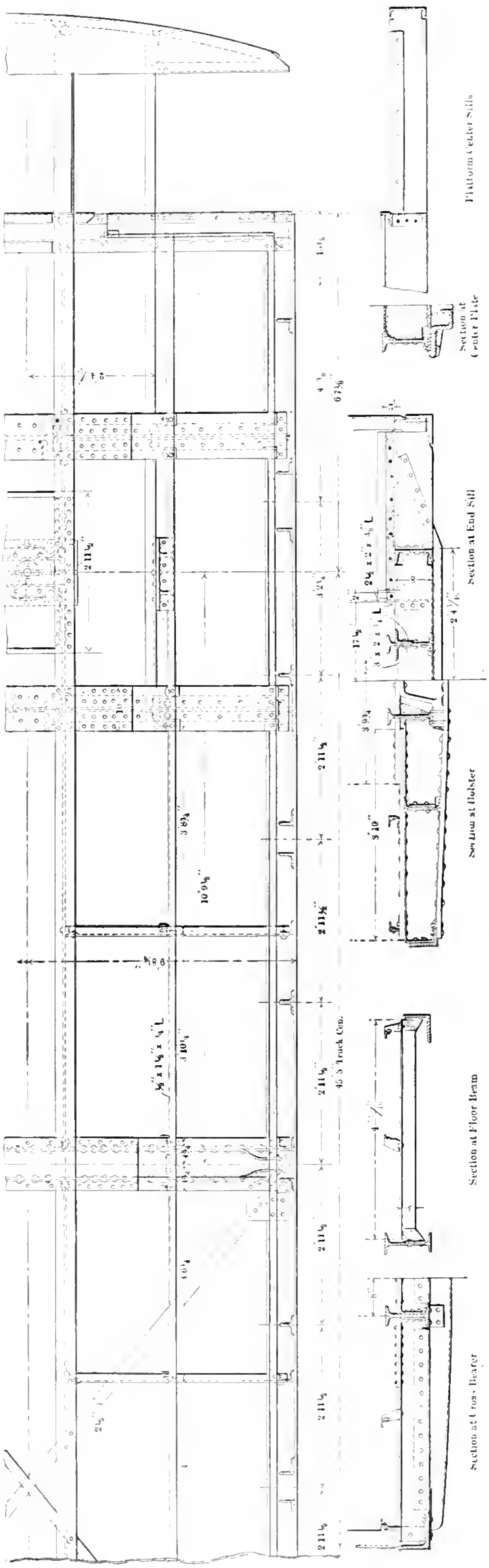
In general, the scheme of design is to support the whole weight of the car body from two girders, which form the sides of the car below the window sills. These girders are in turn supported by the large double bolsters, which carry the weight to the center plate through a short section of the center sills. The weight of the roof, vestibules, floor, center sills and live



STEEL PASSENGER COACH—LONG ISLAND RAILROAD.



END OF STEEL PASSENGER COACH.



UNDERFRAME OF LONG ISLAND STEEL PASSENGER COACH.

load are all transferred to the side girders by means of the side posts, cross bearers and end sills.

These side girders consist of a 3-16-in. web plate forming the side of the car below the windows and a tension member, consisting of a 6 x 6-in. angle iron, which forms the side sill of the car. The compression member of the girder, which becomes the tension member for a short distance over the bolsters, consists of two pieces, a specially rolled bulb angle on the outside and a 7-16 x 3-in. continuous steel bar on the inside of the plate, the two being securely riveted together with the plate between them. The web of the girder is stiffened by the side posts of angle and T irons, which are offset at the bottom and top to clear the lower angle and the upper bar, and are securely riveted to both the plate and the other members. The whole girder is stiffened sidewise by the cross bearers, of which there are three, the end sills, floor beams, and by the carlines acting through the side posts.

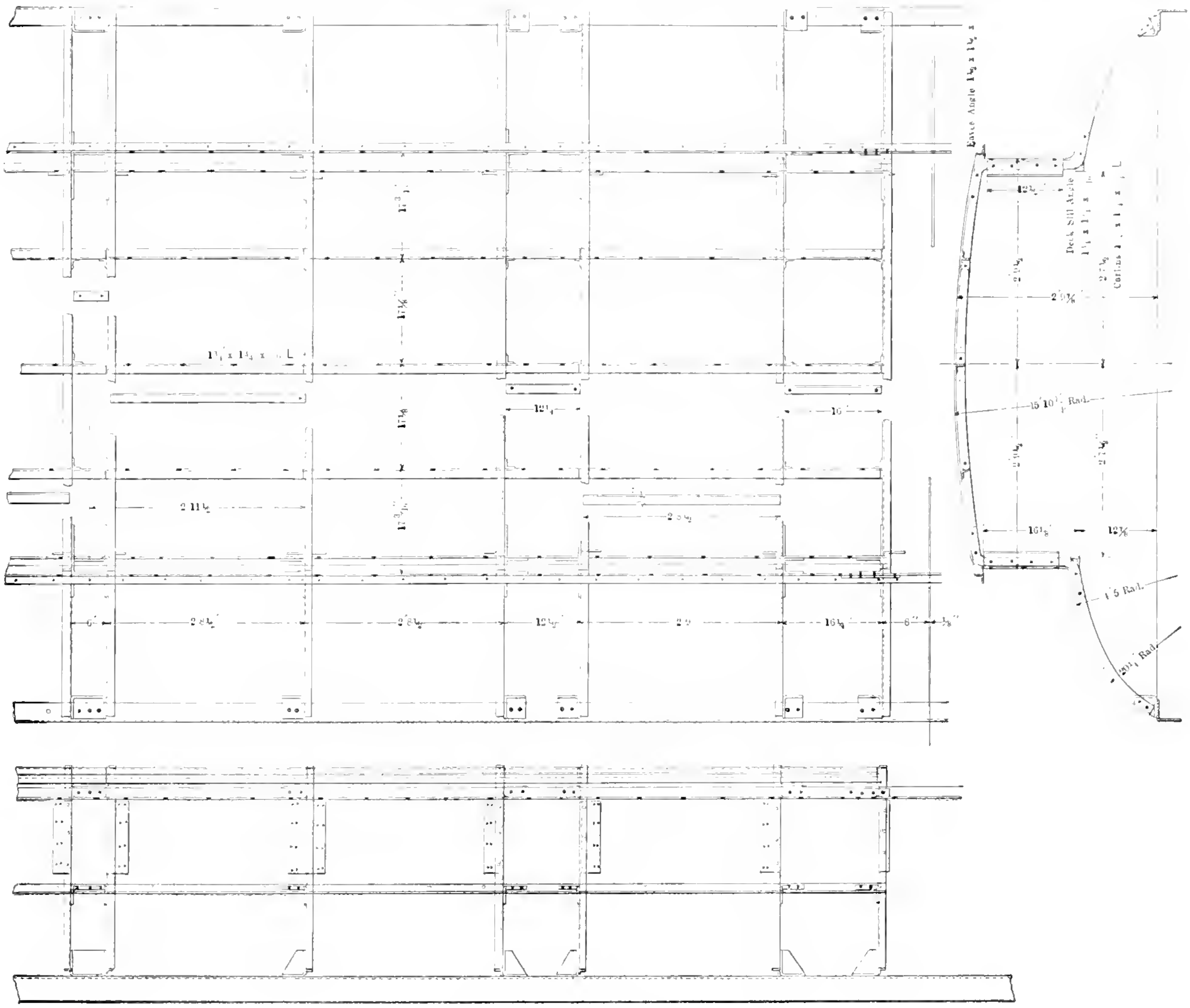
The weight of the vestibule is carried quite largely by its roof construction, which transfers the load through the corner posts and door posts, and thence by the end sills to the side girder. The weight of the platform, which also includes some of the vestibule, is carried by two auxiliary or intermediate sills, consisting of 8-in. channels, which are supported at the end sill and transfer their weight by that means to the side girders. These also extend inward, and are connected to both sections of the bolster.

The general features of the construction of the whole car are very clearly shown by the illustrations, and it will not be necessary to consider them in any great detail. The following general description, however, will be given largely as a supplement to the drawings:

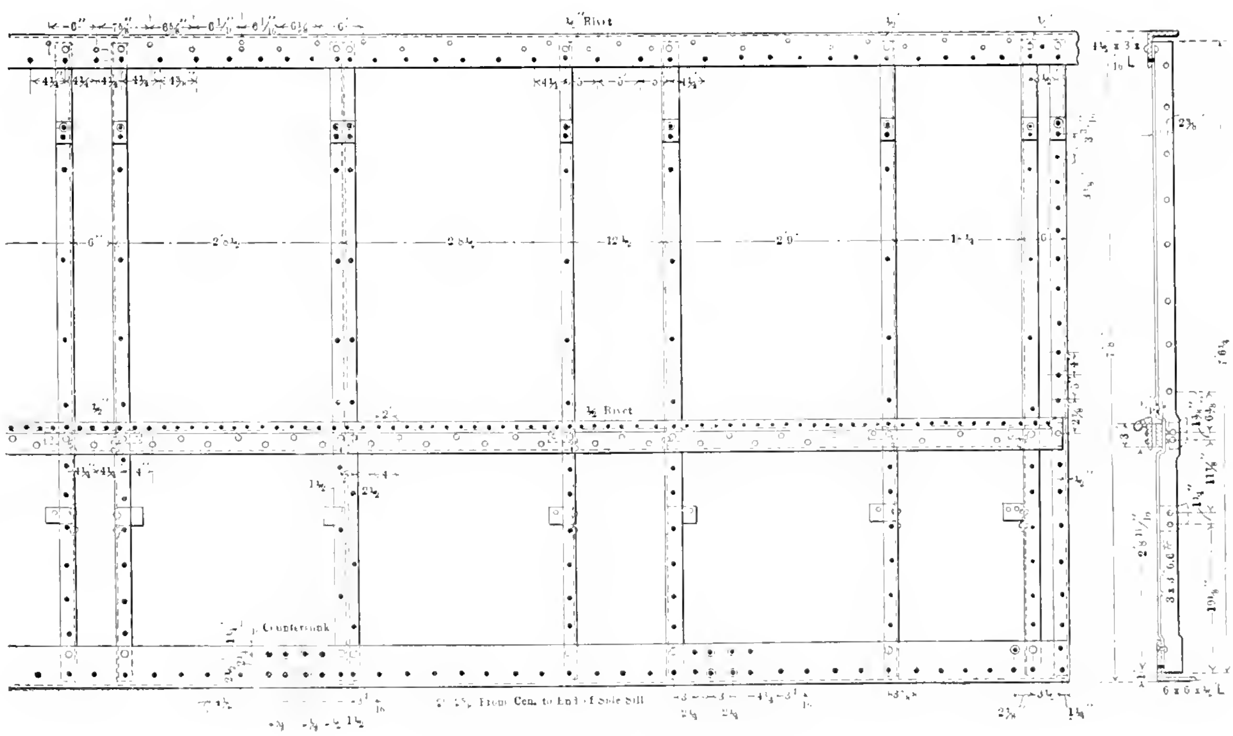
The underframe comprises the 6 x 6-in. angles forming the lower part of the side girder, which act as side sills. The 10-in. I beams set at 16-in. centers act as center sills. The three cross bearers are equally spaced between the bolsters, and a pair of diagonal braces connect at the junction of the cross bearers and side sills by means of gusset plates. The floor, which is formed of "Acandlith" cement spread on corrugated sheets of galvanized iron, made of a special keystone section, is supported on the center sills and by longitudinal angles resting on the cross bearers and bolsters, there being one at the side posts and one intermediate between that and the center sills. These longitudinal angles are further supported by the floor beams connecting between the center and side sills, and consisting of 3-in. angles. This construction leaves an open space of about 3½ ins. below the floor, in which cables, pipe lines, etc., can be installed without difficulty, if desired.

The cross bearers consist of flange plates placed between the side and center sills and riveted thereto, as well as a spacing plate of similar construction between the center sills, below which there is a special trough section, which is continuous from side to side of the car below the center sills and is securely fastened to the side sills. A short cover plate is passed through the web of the center sills and riveted to the outstanding flanges of the side fillers.

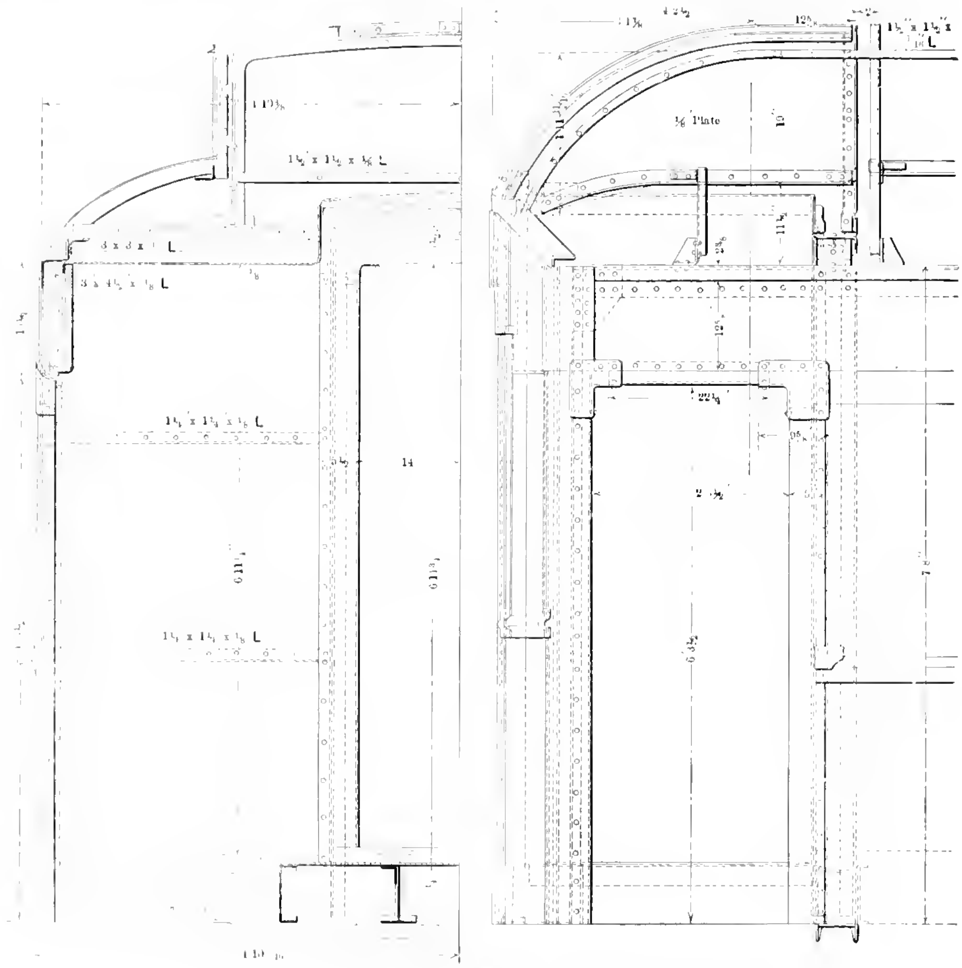
The bolsters are also formed of pressed steel fillers or web plates, there being a pair between the side sill and the platform intermediate sill, another between that sill and the center sills and a cast iron spacing piece between and below the center sills. A heavy bottom cover plate 1 x 10 ins. is carried from side to side of the car and securely riveted to the side sills and filling pieces. The top cover plate, ¾ x 10 ins. in size, is formed in three sections with a lapped splice, the center section extending through the web of the center sills. This construction is so designed for the purpose of making it possible to remove these cover plates if necessary without disturbing the side sheathing. The two bolsters are about 5 ft. apart, and, as above mentioned, transfer their load to the center sills at this point. For a distance of 3 ft. on the bottom of these sills, between the bolsters, there is a heavy cover plate, to which the center plate is fastened, and sills are further reinforced by a top plate of channel shape riveted to the webs of both sills.



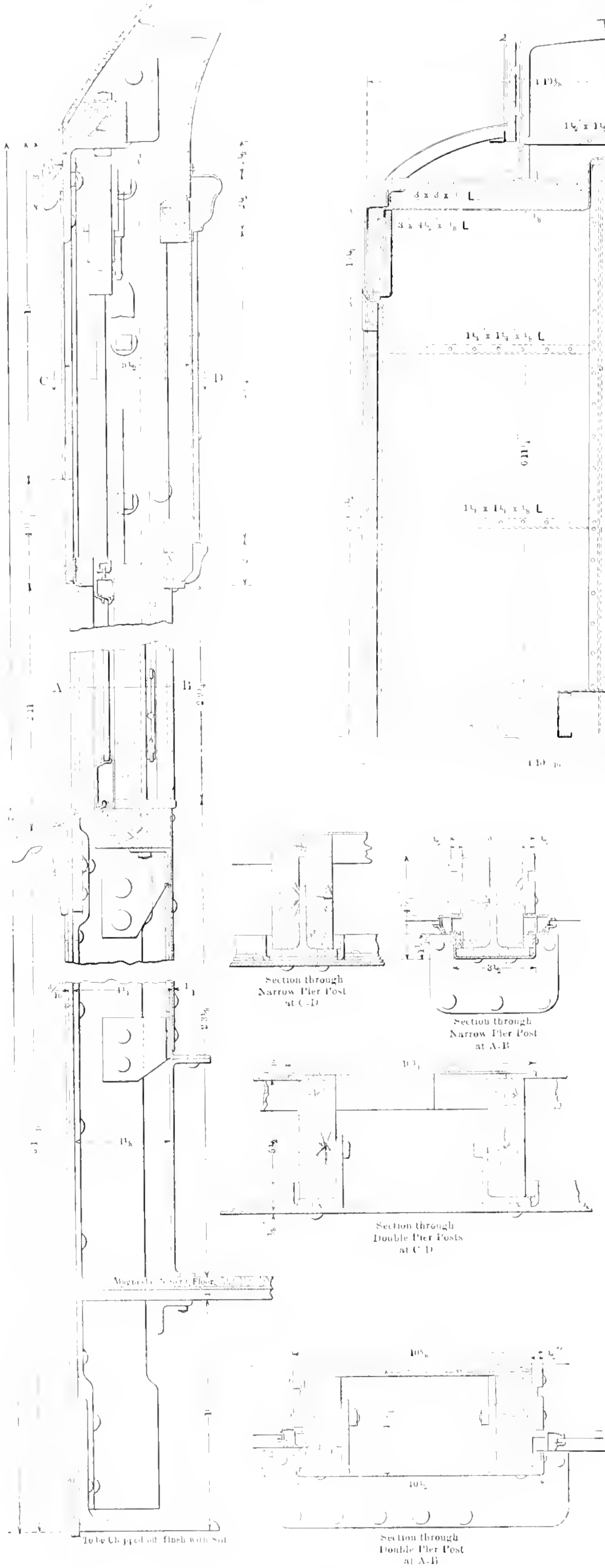
ROOF FRAMING—LONG ISLAND STEEL COACH.



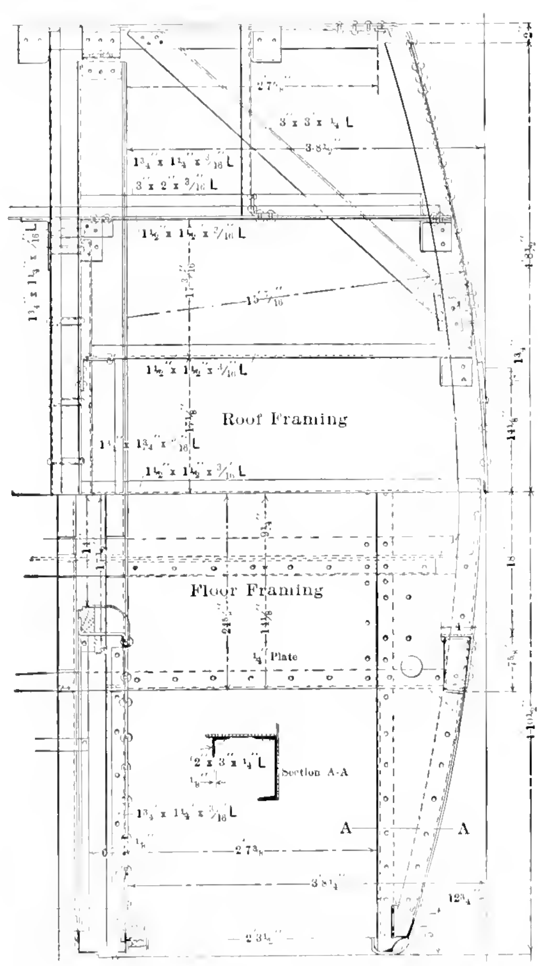
SIDE FRAMING—LONG ISLAND STEEL COACH.



VESTIBULE FRAMING.



DETAILS OF SIDE FRAMING.



PLAN OF PLATFORM AND VESTIBULE ROOF FRAMING.

The end sills also consist of double flanged plates between the longitudinal sills, and include a channel which passes continuous below the center and platform sills and is turned up at either end and securely riveted to the flanged plates.

The draft gear, as previously mentioned, is of the Westinghouse friction type, and because of the height of the center sills narrow draft sills were necessary, these being formed of pressed steel shapes and securely riveted to the bottom of the center sills, extending back beyond the draft gear and having a cover plate so arranged as to assist in transferring the buffing stress over some distance on the center sill. The draft gear cheek plates connect partially to the center sills and partially to these draft sills, the center line of the draft gear being nearly on a line with the lower edge of the center sill. The buffer is of the Gould friction type, and is located a short distance above the center line of the center sills, so that in case of a heavy buffing stress it will be transferred to very nearly the center line of the sills.

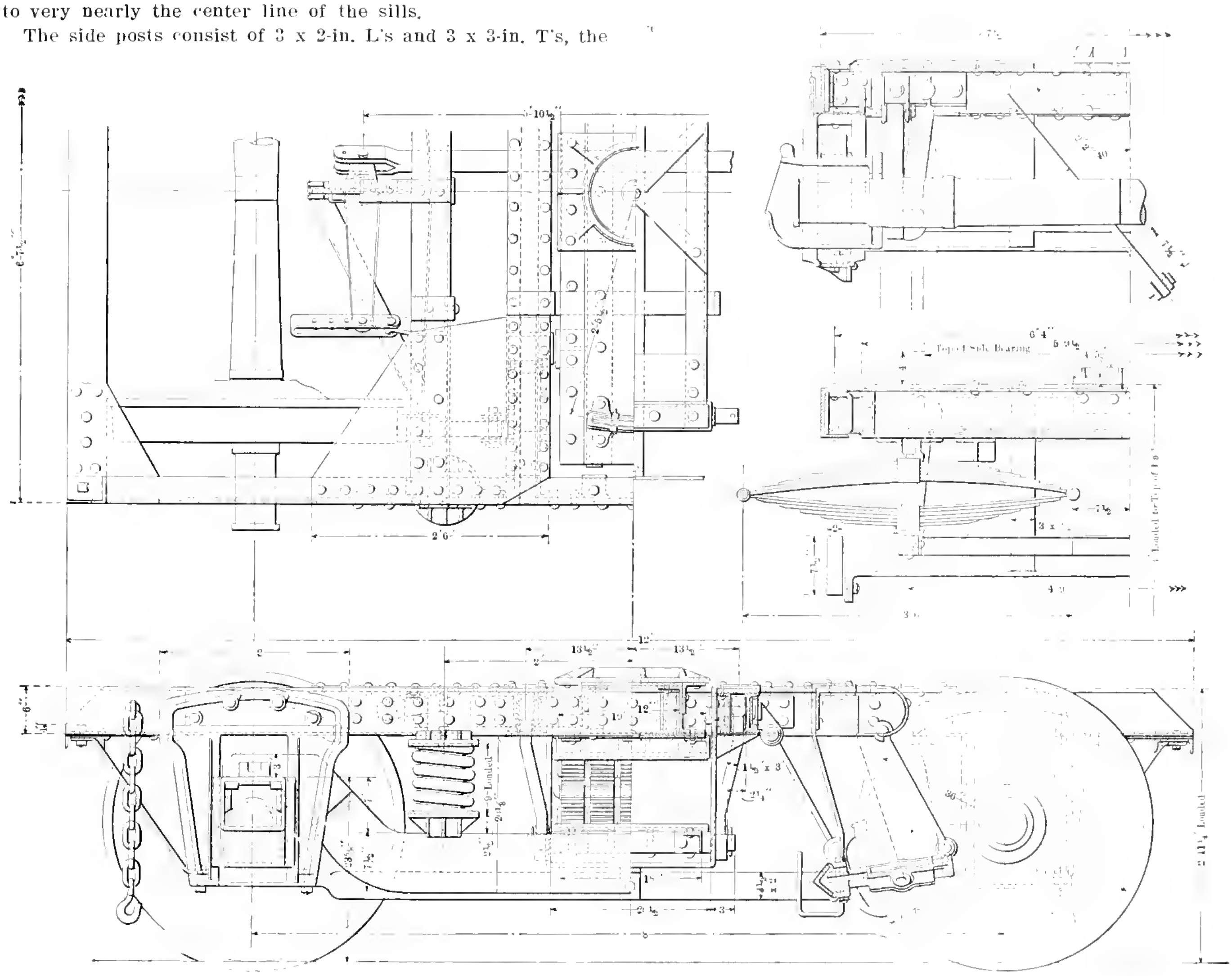
The side posts consist of 3 x 2-in. L's and 3 x 3-in. T's, the latter forming the single posts and two of the former, spaced at various distances apart, forming the double posts. These are offset at the bottom and belt rail, as previously mentioned. At the top they connect to a side plate angle of 4½ x 3-in. section, which extends continuous from end to end of the car.

The carlines, consisting of light angles in one piece from side plate to side plate, are bent to the proper contour and connected to the side plate by light pressed connections. There is a carline at the junction of each side post. The bracing and stiffening of the roof construction is clearly shown in one of the illustrations. Special attention, however, might be drawn to the fact that there is a vertical ⅛-in. steel plate forming the side of the clerestory in the vestibule. This plate, with its angle iron connections, acts as a cantilever for supporting the weight of the vestibule, and also is of great value as a stiffener to prevent the collapse or crushing of the vestibule in collisions.

The interior finish is of steel, with the exception of the head lining, which is of a material known as "Durite." The pressed steel mouldings, battens, etc., are connected to the steel framing in many cases by means of wooden fillers, as is shown in the enlarged section through the side of the car. However, it might be mentioned that some of the sections shown in this illustration as being of wood were actually constructed of pressed or drawn steel. In fact, there is absolutely no wood used that is not encased in metal. The window sashes and the window sills are both of steel. The interior is painted in an excellent imitation of mahogany, and to all appearances is finished in wood, giving it the same pleasing appearance that is found in modern passenger cars.

The outside roof is of "Durite," over which is spread a canvas cover, the corners, hoods and hips having copper flashings. The construction in this respect is that usually found on wooden cars. The seats have a steel frame and plush cushions and backs, being furnished by Hale & Kilburn, and conforming to the standards of the Pennsylvania Railroad. The luggage racks are continuous.

The specialties used in this car outside of those already mentioned consist of the Gold car heating system; Pantasote curtains with Forsythe fixtures; Dahlstrom all-steel doors; Symington journal boxes; Baltimore Railway Specialty Company's side bearings; Schoen rolled steel wheels; Adams & Westlake hardware; Stanwood step treads; Westinghouse quick action brakes and air signals; Columbia lock nuts on all bolts throughout the whole car. The Universal Electric



TRUCK FOR LONG ISLAND STEEL PASSENGER COACH.

INTERIOR OF LONG ISLAND STEEL PASSENGER COACH.

Storage Battery Company's lighting system is used, which consists of 32 cells, with a capacity of 600 ampere hours, and is capable of lighting all of the lights in the car for a continuous period of 30 hours without recharging.

The trucks, as can be seen in the illustration, follow the general lines of a standard equalized passenger truck, with a wheel base of 8 ft. They are steel throughout, and of a very open, simple construction.

The general dimensions and weights of this car are as follows:

Length over buffers	67 ft. 4¼ ins.
Length over body	58 ft. 5¾ ins.
Width over sheathing	9 ft. 8⅝ ins.
Width over all	10 ft. 2⅞ ins.
Height rail to top of roof	14 ft. 0¼ in.
Height rail to bottom of side sills	3 ft. 5½ ins.
Truck centers	45 ft. 3 ins.
Height rail to top of platform	4 ft. 1¾ ins.
Clear width of aisle	25⅝ ins.
Seating capacity	72 persons
Weight of body	66,800 lbs.
Weight of trucks	22,000 lbs.
Storage batteries, including boxes, hangers, etc	5,700 lbs.
Total weight in running order	94,500 lbs.

RAILROADING FROM A BUSINESS POINT OF VIEW.

Railroading consists essentially in the manufacture and the sale of transportation, and it is obvious that it should be made as cheaply as possible and sold for as good a price as the market will afford. To accomplish either of these purposes involves the same knowledge of facts that must be possessed in the manufacture of any other commodity. I believe that it is true that in no business of equal magnitude are books kept with so little reference to the collection of useful facts. The accounts that are kept are, in the most part, of very little value, because very ordinary investigations may prove them to be incorrect in detail, and even when one essays to obtain a statement of the cost of repairing any particular engine or engines, or any of the many facilities which are employed by any great railroad, the result will be disheartening in the extreme. Nevertheless, every railroad in the country goes on piling up figures which are meaningless, and which are not and cannot be used for the only purpose for which they should be made, viz., to make it possible to determine with approximate exactitude the relation between the cost and the selling price.

To my mind, the practice pursued by most roads in an endeavor to secure minute supervision of its affairs is shortsighted in the extreme and results in the perfunctory performance of many duties by officials receiving high salaries, who could be much more profitably employed in looking after other matters. Cases repeatedly come to my attention in which requisitions are made for certain articles which are indispensable and in current use. These requisitions possibly require the signature of at least a half dozen different officials, and it is quite probable that a month may elapse from the time the requisition is made until it receives all the approvals which are deemed necessary in order to enable the purchasing agent or storekeeper to furnish it. Of course, some requisitions are disallowed, and properly so; but all that is saved through this procedure is wasted many times over by the delays which result in securing the things that are really necessary.

My own idea in regard to matters of this kind is that there should be some official connected with the auditing department and allied with the purchasing and store departments, who will have authority to approve requisitions which should come to him usually with not more than two signatures; first, that of the man who originates the request; and second, that of his immediate department superior. If error is made, or if a man is extravagant, the fact will be very soon ascertained and the proper corrective applied. As hereinbefore stated, many records are made which are absolutely valueless. A great many of them were legitimate enough when they were inaugurated, but the necessity for them has passed, and they are still kept up as a matter of form.—*Mr. J. W. Kendrick, second vice-president of the Santa Fe, before the New York Railroad Club.*

BRAKE SHOES ON THE SUBWAY.—Twenty tons of brake shoes per month are stated to be used up in the New York Subway. The brakes are applied, it is said, for nearly one-quarter of the total time of running upon the local train runs and for about one-eighth of the total running time of the express trains.—*Eng. Record.*

SUPERHEATED STEAM IN LOCOMOTIVE SERVICE.—The Carnegie Institution of Washington, D. C., has made a grant of $3,000 a year, for a period of four years, to Dean W. F. M. Goss, of Purdue University, Lafayette, Ind., for the purpose of determining the value of superheated steam in locomotive service; first, in connection with single expansion engines; and second, in connection with compound engines. This is the second grant which the Institution has made to Dean Goss. While given to him personally, its effect will be to stimulate and to make more effective the work of the Purdue Locomotive Laboratory. Funds thus received will be employed in supplementing the resources of the laboratory as derived from all other sources.

RAILROAD SHOP ORGANIZATION.

BY C. J. MORRISON.

A visit to a number of the largest railroad repair shops reveals the fact that in each shop there is a state of more or less dissatisfaction with the amount of work done and its cost. Each shop is endeavoring to improve its output, both in quantity and cost, and is diligently inquiring what the other shops are doing and how they are doing it. A great many methods for procuring the desired results are tried. One shop learns of the way certain work is handled in another shop and adopts the method bodily only to find it a failure when transplanted.

A very interesting comparison of the different methods of handling work is obtained in a large repair shop, which we shall designate as No. 1, having one general machine shop and three separate erecting shops under different foremen. Two of the erecting shops are small, comparatively dark and crowded, while the third is light, thoroughly modern in every respect, and has more floor space per engine than any other railroad repair shop in the country. The two older shops have only fair crane facilities, while the new shop has not only three large cranes, capable of lifting the engines, but four jib cranes, which run over the engines and handle light material. All three shops are longitudinal. The road has a large number of engines of one class, so that the work in the three shops is practically the same. The new shop uses the highly specialized method of a gang for every job. One gang does all the steam chest work, another all frame work, another all cylinder work, and so on. One of the older shops uses practically the same method, but does not specialize to quite as fine a point as the new shop. The other shop uses the method of having each gang take three to five engines and carry through all the work, from stripping to firing up. The same piecework prices prevail in all three shops, and all work is delivered from the machine shop fit up ready to go on the engines. Strange as it may seem, the output from each shop is exactly the same when reduced to a man hour basis. In other words, the efficiency of the man is not increased by improved conditions and specialized methods.

Another railroad in the same district has a shop (No. 2) in an old, dark building, which is so badly out of repair that numerous props are required to keep it from falling down. This is a transverse shop, with no cranes, and so badly designed that often one engine has to be pulled outside before another can be wheeled. Wheeling and unwheeling are done by a drop table, which can handle only one pair of wheels at a time. Wheels and boilers must be pulled out into the yard and switched to the wheel shop and boiler shop, respectively. In fact, the conditions are generally adverse, and the only redeeming feature is the fact that the shop is well provided with modern machines and tools. The piecework system is used, and the prices are somewhat lower than at Shop No. 1. In the erecting shop there are only three gangs; one does the stripping, one all the work below the running boards, and the third all the work above the running boards. All fitting up is done in the machine shop. The engines are about the same weight and general dimensions as on the first road, yet the output of this shop on the man hour basis is far greater than at Shop No. 1. Again it appears as though the conditions do not affect the efficiency of the men.

A third shop (No. 3) in a different section of the country, and using entirely different methods, has practically the same man hour output as Shop No. 2. This last shop is operated on the individual effort method; has a splendid shop building, housing boiler, erecting and machine shop under one roof; poor crane facilities, excellent light, fair machine equipment and ample erecting space. The specialized gang system is used, but the gangs both fit up and erect. For example: The guide and piston gang not only does all the bench work on guides, pistons, cylinder heads, casings and crossheads, but puts them on the engine. Here are two shops, with entirely different methods and conditions, yet with the same efficiency on the man hour basis.

As it is scarcely just to compare piecework with daywork shops, let us consider two daywork shops within ten miles of each other, and handling almost the same class of engine. One has splendid buildings and practically every modern improvement, while the other has old, out-of-date buildings, no cranes, and no modern improvements of any description except that there is a good equipment of machine tools. The second shop gets out 50 per cent. more work on the man hour basis than the first one.

These facts are sufficient to cause one to stop and think. What causes these differences? What influences the efficiency of the men? Not only do some shops get a low efficiency, but the surcharges are enormous, due to the expensive equipment. If the shop methods and equipment do not affect the efficiency, there is only one other source to look to—the organization.

At Shop No. 1 there is divided responsibility, the shop being under the management of two men, neither one of which is in complete charge of any one department or responsible for the output. Each shop has a foreman, who spends most of his time in the office going over time cards, piecework rates and other clerical work. The gang leaders are paid by the day, and earn considerably less than the men under them. Naturally, they have no incentive to push the men, and are jealous of their earnings. As a result the efficiency is low.

At Shop No. 2 one man is directly responsible for the output, and is directly in charge of the work. Under this man are foremen, gang leaders, and an assistant who, in a commercial establishment, would be known as a "pusher." It is his duty to push and see that every man and every machine is going at full capacity. The foremen have nothing to do with piecework rates or timekeeping, but give all their energy to getting out work. They receive a monthly salary which is large enough to keep them from being jealous of the pieceworkers. The gang leaders work piecework and, as their earnings increase with the men's, have every incentive to hustle and push the men.

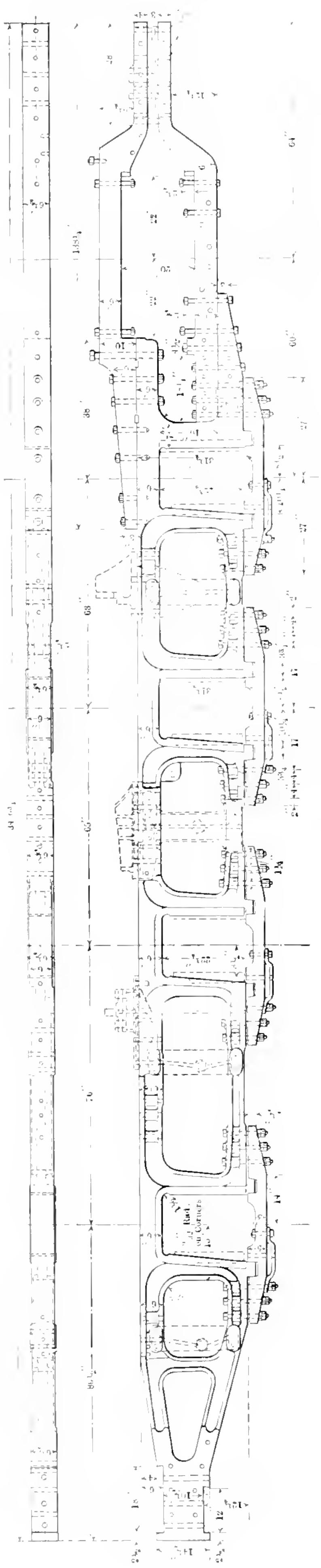
At Shop No. 3 one man is directly responsible for the output. An inspector relieves him of the responsibility of deciding what work shall be done and looking after material. The foreman and gang leaders have no offices and do practically no clerical work. All work is done under the individual effort method, and the foreman's or gang leader's bonus increases directly as the men's. Moreover, he receives an additional bonus for getting out work ahead of the schedule time. The result is high efficiency of the men.

In the first of the daywork shops the chief duties of the foremen seem to be to order material and to assign work to the men. The idea of timing an operation or of trying to push the work seems to have never entered their heads. The men practically work as they please, and an extremely low efficiency results.

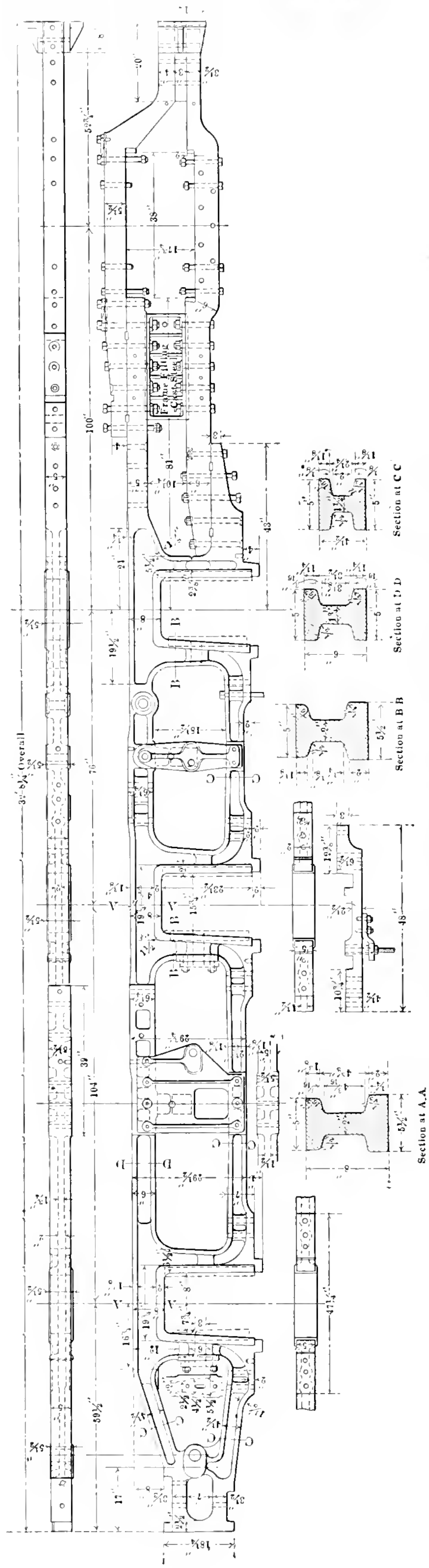
At the other daywork shop an accurate record is kept of each day's work, and if a foreman has fallen below his allotment he is immediately notified. He is also notified if the price is higher than the price on the same article at any former time. This causes the foremen to not only push the work all they possibly can, but also to hold down the price. Even in a daywork shop this can be done in a number of ways.

It would appear that the most important item about a shop is its organization. Organization costs less than equipment and seems to produce better results. Not that good foremen can be gotten for less than mechanics, for they never can; in fact, in order to obtain a good organization, what may appear to be high wages may have to be paid. The ideal condition for producing large output at low cost, therefore, seems to be a cheap building, no expensive cranes, good machine equipment, and an organization that works as a unit and is always on its toes.

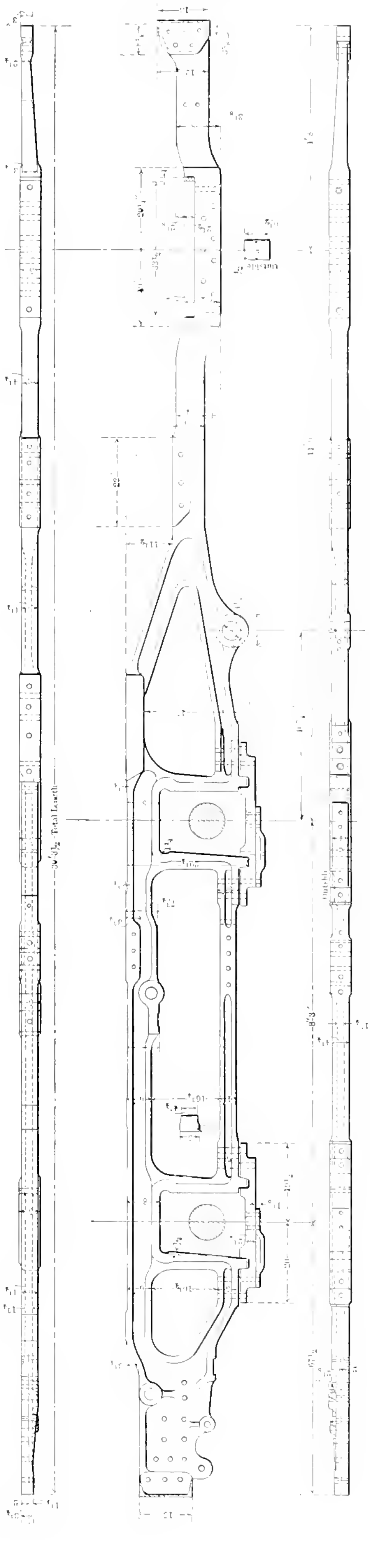
The man in charge that is missed when temporarily absent is a bad organizer.—*Mr. D. T. Taylor.*



CAST STEEL FRAME FOR CONSOLIDATION LOCOMOTIVE—DELAWARE AND HUDSON COMPANY.



CAST STEEL FRAME FOR TEN-WHEEL LOCOMOTIVE—DELAWARE AND HUDSON COMPANY.



CAST STEEL FRAME FOR AMERICAN TYPE LOCOMOTIVE—CENTRAL RAILROAD OF NEW JERSEY.

CAST STEEL LOCOMOTIVE FRAMES.

About five years ago Mr. J. R. Slack, then superintendent of motive power, and Mr. G. S. Edmonds, then mechanical engineer of the Delaware & Hudson Company, took up the subject of frame failures in an energetic manner and made a series of records and studies of all the failures on the road, which resulted in the designing and applying of several cast steel locomotive frames having an I instead of a rectangular section.

The service of these frames was so satisfactory that the design has been continued by the present superintendent of motive power, Mr. J. H. Manning, being improved from time to time, and at present it is very extensively used on that road on all types of engines.

The illustrations show frames used on both the 10-wheel and consolidation locomotives of the D. & H. Co., and also one of similar type that is used on the Central Railroad of New Jersey, being applied to a heavy American type locomotive recently built by the American Locomotive Company. The 10-wheel locomotive on which the frame shown has been applied was illustrated in the AMERICAN ENGINEER AND RAILROAD JOURNAL, February, 1906, page 65. It weighs 173,000 lbs. total, with 130,000 lbs. on drivers, and has 21 x 26-in. cylinders and a tractive effort of 31,000 lbs. The consolidation locomotive was illustrated in January, 1907, page 22, and weighs 246,500 lbs. total, of which 217,500 lbs. is on drivers. The Central Railroad of New Jersey locomotive has 19 x 26-in. cylinders, weighs 108,000 lbs. on drivers and 158,000 total, and has a tractive effort of 23,120 lbs. with 69-in. wheels.

This design of frame was first illustrated by an article in the AMERICAN ENGINEER AND RAILROAD JOURNAL in May, 1901, page 149, which contained illustrations presented for criticism by Mr. Van Ness Delamater, then a student at Cornell University. In September, 1901, page 287, Mr. G. S. Edmonds presented a communication treating the subject from a theoretical standpoint, and showed that for the same amount of metal and the same width of frame the I section was about four times as strong in the horizontal plane, but was a little over half as strong in the vertical plane. In the issue of November, 1901, page 356, was illustrated the first frame of this design used by the Delaware & Hudson Company, which was applied to an American type engine. In October, 1903, page 365, extracts from a paper by Mr. Edmonds, on "A Rational Method of Designing Locomotive Frames," presented before the Pacific Coast Railway Club, were published, in which the subject is summed up as follows:

"Analyzing, we know that:

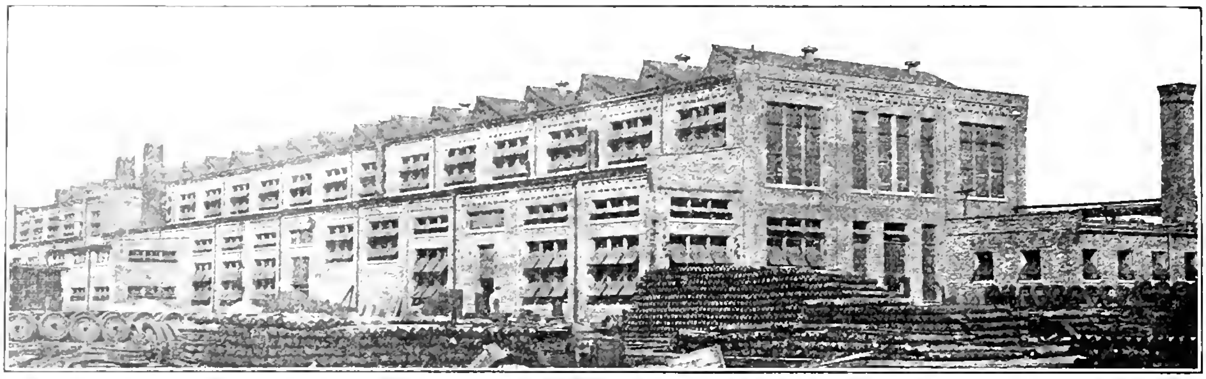
"1. A web section gives us higher moments of inertia per unit weight than any other.

"2. A frame casting is such that the use of coring must be eliminated, else first cost will be excessive, with possibilities of shifted cores.

"3. The second condition reduces the number of available web sections to channel and I sections. When we consider the problem of molding, with shrinkage effects, the latter seems decidedly the more desirable of the two. The comparative thinness of the I casting allows of a ready and careful examination by the inspector, whereas with the rectangular section, oftentimes the outer surface covers a multitude of sins, discovered only when failure of part discloses interior honeycombing. Hence, while of higher factor of safety if sound, the uncertainty of the material, for above reason, favors the I section."

The continuance of the design on the D. & H., especially its use on the very heavy and powerful consolidation locomotives, would indicate that several years of service had proved the truth of the above conclusions.

While it is not as difficult to get sound steel castings to-day as it was a few years ago, and there is probably no great saving in weight with this design, nevertheless, the opportunity to place the metal where it is most needed and in a position to



FOUNDRY, SOUTH LOUISVILLE—LOUISVILLE & NASHVILLE RAILROAD.

give the greatest service, as well as to eliminate superfluous metal where it is not needed, are sufficient to make these frames worthy of careful consideration.

SOUTH LOUISVILLE SHOPS.*

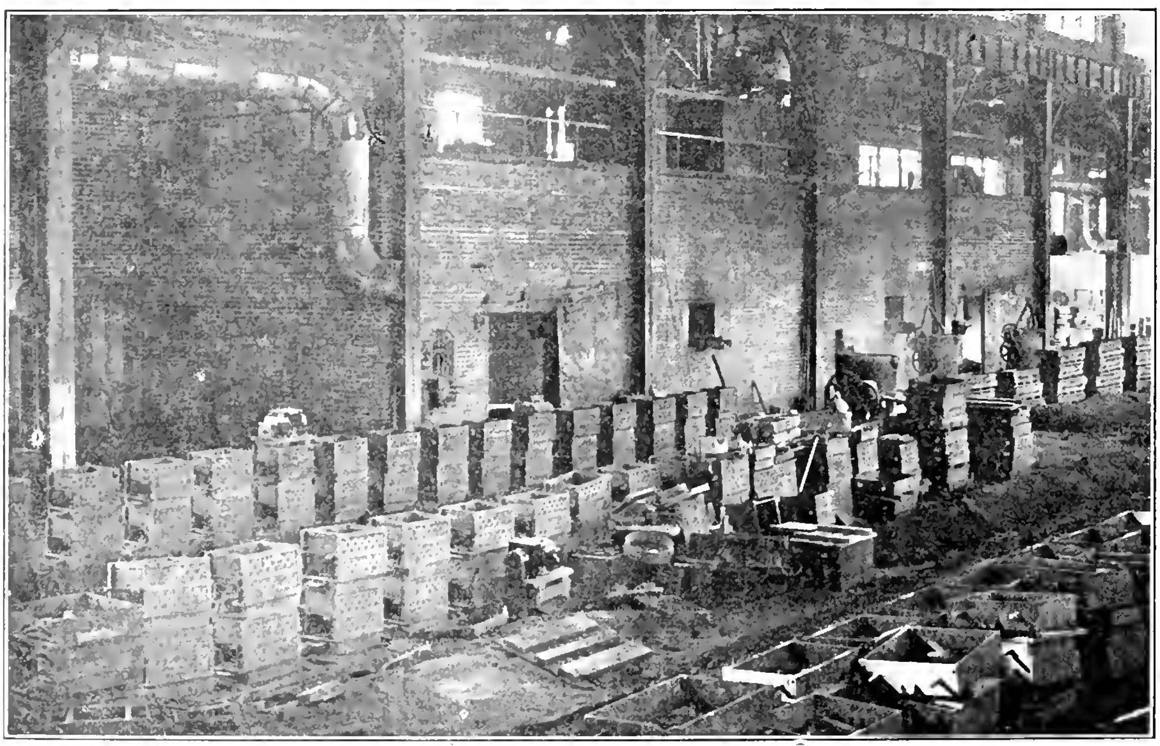
LOUISVILLE & NASHVILLE RAILROAD.

IV.

FOUNDRY AND PATTERN SHOP AND STORAGE BUILDING.

Grey Iron Foundry.—In the first article of this series, page 209, June, 1906, mention was made of the fact that the shops are arranged about an L-shaped system of transportation, consisting of a high-speed transfer table and an overhead traveling crane; also of the fact that all lumber enters at the south end of the plant and all metal at the north end, both progressing steadily toward the point where they will be placed on the finished car or locomotive, or where they will be finished ready for shipment to outside points, when they are either transferred to the storehouse or loaded for shipment at the most convenient place nearest to the point where they are finished.

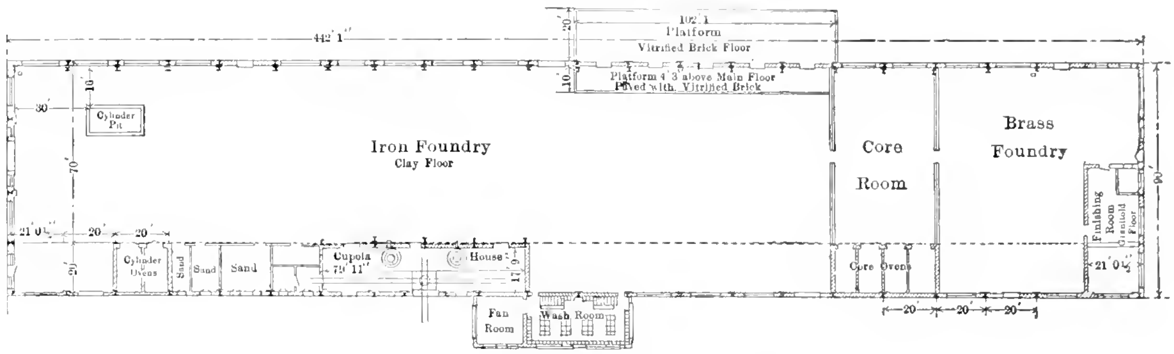
In keeping with the scheme of having the raw material enter at the ends of the plant and travel steadily toward its objective point, without doubling on its tracks, the foundry is placed at the extreme north end of the plant. The raw material for the foundry is stored at the west side of the building, while the finished material comes out on the shipping platform at the east side, and from there is either transferred by the traveling crane and the transfer table, if it is to be used in the plant, or if intended for shipment to outside points is loaded directly into the cars. Brass castings for shipment to other points, or if not immediately required for use in the plant, are transferred to the storehouse by the traveling crane and the transfer table. In order that the journal boxes may be transferred from the foundry direct to the truck erecting department, or be shipped direct from the foundry, a drill press is placed in the finishing end of the foundry, and the bolt holes are reamed out. The traveling crane, which is 1,000 ft. long and extends to the transfer table, passes over the foundry shipping platform and ends near the middle of the building, as shown on the general plan, page 208, June, 1906.



INTERIOR OF GREY IRON FOUNDRY—SOUTH LOUISVILLE.

The building is a steel frame brick structure, about 90 by 440 ft., the main portion being formed of a single span, 70 ft. wide, with an addition 20 ft. wide opening into the main portion and extending along the western side. The roof of the main portion is of the saw tooth type, the sides containing the glass facing north. A composition roofing is used on the

* The previous articles of this series were: General Plan and Operation, page 209, June, 1906. Car Department, page 379, October, 1906. Power House, page 419, November, 1906.



PLAN OF FOUNDRIES—SOUTH LOUISVILLE.

main part, while the roof of the addition is of Book tile covered with composition roofing.

The building is divided by two brick walls, 3 ft. 6 ins. high, into three parts, the top of these walls being covered with iron coping and having a wire partition extending 6 ft. 6 ins. above them. The grey iron foundry is about 320 ft. long, the core room 40 ft., and the brass foundry about 80 ft.

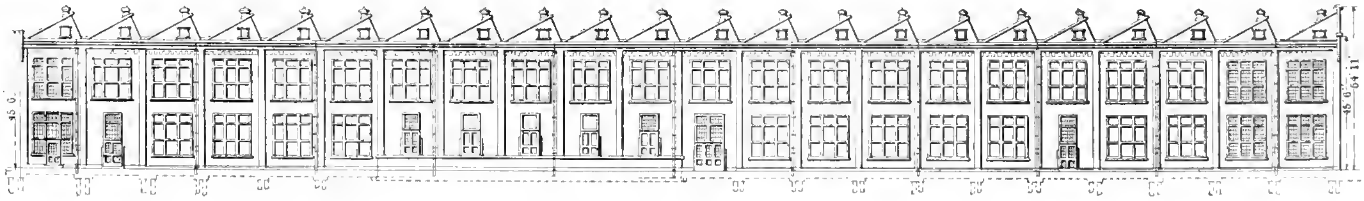
Two 54-in. 80,000 lbs. capacity cupolas, built by the Whiting Foundry Company, are placed at about the middle of the west side of the iron foundry, as shown on the plan view. At present about 60 tons of grey iron castings are being turned out per day. Small cars containing the charges are brought in from the stock yard over a system of narrow-gauge tracks. These cars are weighed on the scale at the entrance to the cupola room, and are then run on an electric elevator, just back of and between the two cupolas, and are elevated to the charging floor. Tracks extend from the elevator to each of the cupolas, and a turn-table on the elevator makes it possible to run the car to either one of them. The cupolas are operated by two No. 8 motor-driven Sturtevant blast fans, which are suspended from the charging room floor. Spouts project from the cupolas through the brick wall of the cupola room and discharge into Whiting truck ladles, three tons' capacity, which run on a narrow-gauge track extending to near the north end of the building. The ladles are poured by means of the Niles 20-ton traveling crane, which has a span of 67 ft. 2 ins., and extends the entire length of the building.

END ELEVATION OF FOUNDRY BUILDING.

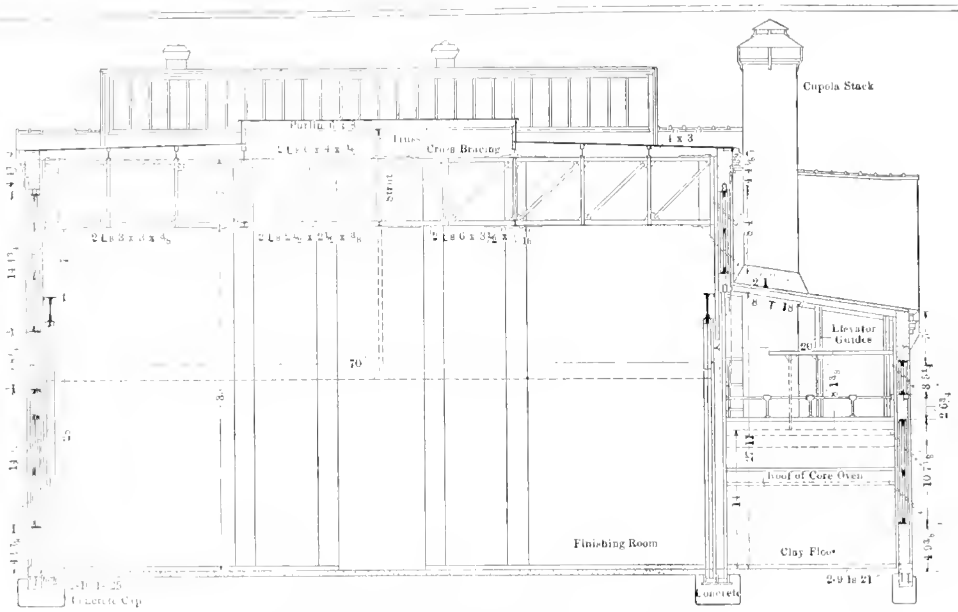
The cores for the grey iron castings, except for the very large ones, and for the larger brass castings are made in the core room between the grey iron and brass foundries, and baked in the four large ovens. These are heated by open fires placed in one end of the oven. The core racks are placed on trucks, which are run into the oven over narrow-gauge tracks. These racks are arranged in sections, so that when the cores have been baked the different sections may be lifted off by the traveling crane and be transferred to the most convenient points on the moulding floor. The cores for the larger castings are made near the north end of the building and baked in ovens at that point.

The tumblers, cleaning benches, emery wheels and the drill for reaming holes in journal boxes are placed at the south end of the iron foundry. The smaller castings are made at this end of the foundry, while the larger ones are made at the other end, a special pit being provided for moulding and casting cylinders.

After pouring off the moulds are opened up, and the night force sorts and places the various castings in metal boxes or buckets. These are transferred by the crane to the platform,



SIDE ELEVATION OF FOUNDRY BUILDING.



CROSS-SECTION OF FOUNDRY BUILDING.

inside the foundry, and emptied into six tumblers. After they have been cleaned the tumblers are opened up and the castings are dropped through chutes to the main floor. The fins and sprues are then ground off on emery wheels, and the castings are given such hand cleaning as may be found necessary, and are then thrown into buckets and transferred by the crane to the shipping platform. The flasks are stored just outside of the north end of the building.

The building is heated by the Sturtevant hot air system; the fan room is at the west side of the building. Several of the hot air pipes are shown in one of the accompanying photographs. A two-story addition, adjacent to the fan room, is used for wash and locker rooms, expanded metal lockers being used.

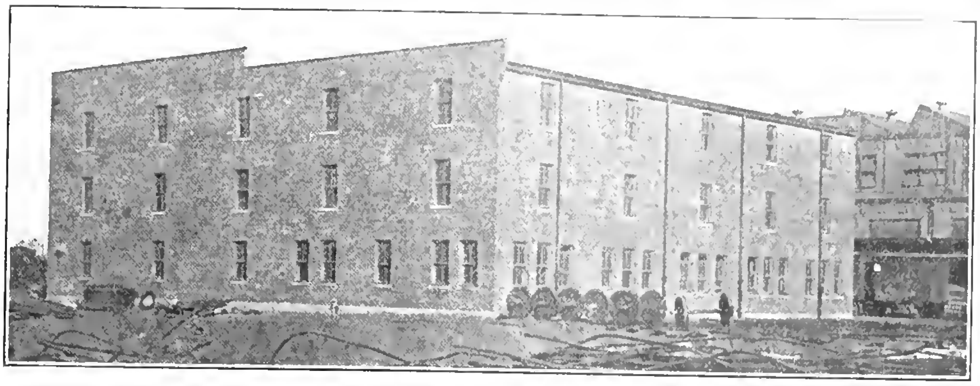
Brass Foundry.—This foundry has an output of five or six tons per day. It contains a double Rockwell rotary melting furnace, a Schwartz rotary and a Porteous portable melting furnace. The small cores for this department are baked in an Eli Millets' patent oven. The castings are cleaned in two 20 x 32-in. tumblers, and from these are emptied directly into the finishing room, which has a granitoid floor, and is equipped with an F. B. Schuster sprue cutter. The car brasses, after being cleaned, are bored on a Niles lathe made specially for this purpose. This lathe finishes eight brasses at a time, and with two operators can easily finish 800 brasses per day. The brasses, after being lined with soft metal, are placed in iron buckets and transferred by the overhead crane to the doorway, and are then pushed out and carried by the traveling crane to the car department or to the storehouse, as may be desired. The finishing room is equipped with a magnetic separator made by the Dings Electro-Magnetic Separator Company, and also with the necessary equipment for casting packing rings and a 14-in. lathe for turning them.

Pattern Building.—The pattern building is about 100 ft. square and three stories high. Except for the pattern shop floor and office, on the ground floor, it is practically fireproof. The window frames and sash, as well as the doors, are covered with galvanized iron. The building is a steel frame brick structure, and the floors, except for about 20 per cent. of the first floor, in the pattern shop, are of granitoid. In addition to the stairways there is an 8 x 10-ft. electric elevator from the first to the third floor. A narrow-gauge track extends from the foundry to this elevator. A room is also partitioned off on the first floor for the laboratory of the engineer of tests.

In the pattern shop the benches are placed along the three sides of the room in front of the windows; the machine tools are placed in the middle of the room and along the partition wall. The windows are of wire glass. Reference to the drawings will show that the number of windows in the part of the building devoted to the pattern shop is much greater proportionately than for other parts of the building. One end of the shop is devoted to the necessary apparatus for making metal patterns. The machine tools are arranged in one group and driven by a 14-h.p. motor. The list of tools in this shop is as follows:

Pattern makers' gap lathe, 25 to 50 ins. swing, 10 ft. bed—Putnam Machine Company.
16 in. x 8 ft. wood lathe.
12 in. x 4 ft. metal lathe—Sellers.
20 in. Oliver hand planer and jointer—American Machinery Company.
24 in. hand surface planer—J. A. Fay & Co.
Oliver universal saw bench—American Wood Working Machinery Company.
Band saw No. 0—Fay & Egan Company.

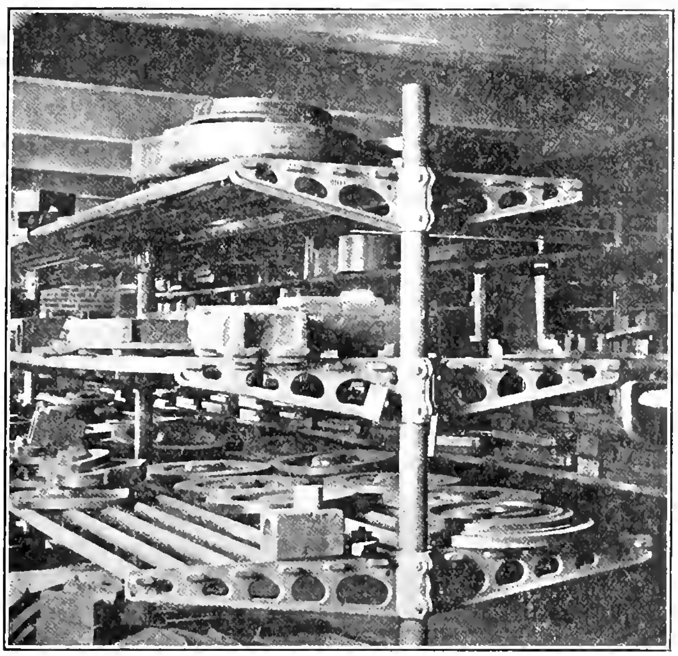
PART LONGITUDINAL SECTION OF FOUNDRY BUILDING.



PATTERN SHOP AND STORAGE BUILDING.

20 in. drill—W. F. & J. Barnes, No. 1.
Fox trimmer—Grand Rapids Machinery Company.
18 in. crank shaper—American.
Grindstone.

The heavy patterns are stored on the first floor. A very neat and cheap rack is used for storing the lighter patterns on the second and third floors. These racks are made of several castings clamped to a piece of heavy pipe, as shown in one of the illustrations. The base casting, which unfortunately is not



PATTERN STORAGE RACK.

shown, is similar to the other castings, but turned upside down. The ends of old boiler flues are shaped to fit over the lugs on the castings, and the rack is tied together by several longitudinal rods. As scrapped flues are used, and the castings are of very simple design, the rack is inexpensive, and at the same time is especially well adapted for the purpose. For very small castings boards are laid over the flues.

Each floor of the building is equipped with fire hose and connections. Incandescent electric lights are used.

STEAM TURBINES.—So far steam turbines of the Parsons type have been manufactured to give a total of 870,000 h.p. Of this 200,000 h.p. came from American builders, and 350,000 h.p. from the original Parsons' Works in England.—*Machinery.*

PLANER OUTPUT.

The following interesting suggestion is reproduced from a catalog describing the high speed planers made by Bateman's Machine Tool Company, Ltd., Leeds, England:

The old practice of judging the comparative values of planing machines, by comparing their speeds on cut and return, has been found very misleading. This is because of the momentary stoppage of the table at each end of the stroke and the time lost before full speed is attained after reversal. In some machines these losses are very considerable and materially reduce the productiveness of the tool, and if such machines were sped up the loss on reversal would be enormously increased. The only accurate means of ascertaining the earning capacity of a planer is to take the cycle times as indicated below:

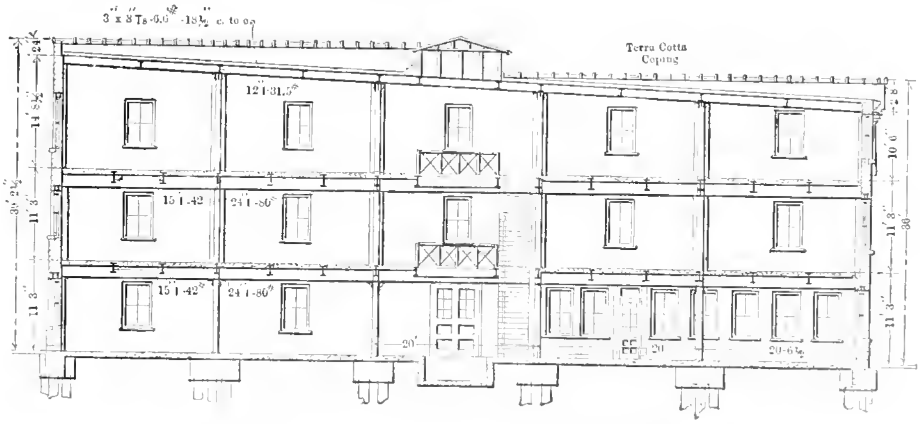
Time of cycle = time of 1 cut + time of 1 return.
L = length of stroke in feet.
T = time of N cycles in seconds.
N = number of cycles.

$$\text{Average (or earning) speed} = \frac{2L \times N \times 60}{T}$$

Thus a 42 in. x 14 ft. machine completes 10 cycles in 3 min. 56 secs. (236 secs.) when on a 14 ft. stroke. Therefore the

$$\text{average speed is } \frac{14 \times 2 \times 10 \times 60}{236} = 71 \text{ ft. per min.}$$

ACCURATE COST KEEPING.—The fiery test is competition, the prices at which the competitor gets the business. In railroading, whatever the condition of freight rates, the measure of success is production of transportation at least cost. When the mill cannot bid low enough to get the contract it must shut down. The railroad shops must keep going, thus the monthly or annual comparative statements seem to lose the biting sting of the selling price. Accurate and detailed cost-keeping is necessary to prevent the home manufacture of articles at a cost extravagant in comparison to the price for which the article can be bought outside.—*Paul R. Brooks, before the New York Railroad Club.*



CROSS-SECTION OF PATTERN STORAGE BUILDING.

THE RAILROAD Y. M. C. A.*

BY FRANK E. HAFF.†

I have the greatest respect for the Young Men's Christian Association as an institution and the truest admiration for its work. I respect and admire it because it does things; because it has and can give an honest excuse for its existence; because it never stands solely upon its past record, but keeps up a continuous forward march; because it surrounds its members with a clear and healthful atmosphere; because it makes men healthy in body and soul, and because it teaches the real fatherhood of God and universal brotherhood of man.

In the operation of railroads many employes must necessarily spend considerable time away from their homes. Engineers, firemen, conductors and brakemen are frequently compelled to lay over from ten to twenty-four hours for the train which they may be scheduled to take back to their home point. Even when the character of the service permits them to return every night, there are of necessity many hours of leisure between runs at terminal points. Formerly these men were obliged by the utter absence of other accommodations to sleep in freight cabooses, coaches and undesirable boarding houses; and as for their hours of leisure, more often from necessity than choice, the most frequent place of resort was the saloon.

But nearly thirty-five years ago the Young Men's Christian Association began to take a special interest in railroad men. With that prescience for which it has become noted the world over, it recognized and grasped its opportunity. It organized a railroad department with the avowed purpose of ameliorating the intolerable conditions surrounding the lives of men engaged in the transportation service. As usual and because the cause was righteous, it succeeded. It awakened in both employer and employe a sense of the great danger to life and property lurking in the continued existence of those reprehensible conditions. The awakening was quickly followed by action, and in hundreds of instances the old order of things has become a mere memory. To-day tens of thousands of railroad men, on whose physical and moral condition depends the safety of millions of lives daily, find in the Railroad Young Men's Christian Association attractive and comfortable homes for their leisure hours. In these homes are provided a good restaurant, library, baths, bowling alleys, sleeping, rest, reading, smoking, game, and even in some cases emergency hospital rooms. But it is not alone the physical side that is looked after, for there is also provided every incentive for moral, mental and spiritual quickening. And what is the result? The placing of property of immense value and especially the lives of millions of people daily in charge of men who are sober and clear-headed; the sending out of train crews, clean, well-slept, alert; the gathering of young men during their leisure hours where physical exercise, recreation and Christian fellowship supplant the influence of the saloon, the gaming place, or worse. Is not the work justified by the result?

There are now 225 Railroad Y. M. C. A. organizations dotting the map of the North American continent, from Montreal to the City of Mexico, and from Portland, Me., to Los Angeles, Cal. Eighty-three thousand men are enrolled as members. During the past year ten thousand were added to the roster. While many of the buildings occupied by this army of railroad men are located at isolated and unattractive division or terminal points, their value exceeds $2,000,000. Sixteen new buildings are being constructed at a cost of more than half a million dollars. From this brief statistical statement may be gathered a fair idea of the present magnitude of the work.

Just a word with reference to the attitude of the railroad corporations toward this work. The president of one of the large Southern systems said in this connection a short time ago: "Since the introduction of Railroad Y. M. C. A. work on this line the loss due to wrecks caused by drunkenness on the part of employees has been reduced from nearly $1,000 per day to a little more than $100 per day." Is not that a splendid material result? But think of the moral uplift — of the great change in the character and lives of the men which made such a result possible.

One of the greatest tributes paid by a railroad official to the value of this work was by Mr. W. C. Brown, vice-president of the New York Central Lines, at the opening of a new Railroad Association building on the Lake Shore at Collinwood, Ohio, toward which his company has contributed nearly $40,000. Mr. Brown said: "I am glad to be with you to-night to participate in the dedication of this building to the service of God and to the comfort and convenience and betterment of the condition of railroad men. Eliminate from consideration if you will the religious and educational features entirely—inestimably important as they are — considering only the simple proposition of a clean, wholesome place to sleep and eat, free from the temptations which surround the young man employed on a railroad, under the most favorable circumstance, when thrown upon his own resources, and in my opinion no investment of a similar amount of money has ever paid or can ever pay so large a return as the money devoted to the construction and maintenance of these railroad departments of the Young Men's Christian Association. The railroad which annually draws thousands of young men from the villages and farms to fill up its ranks, depleted by age, accident and disease, owes something to this army of young men. They owe it to the men themselves; they owe it to the anxious, loving fathers and mothers back in the homes from whence these young men came; above all, they owe it to the public who daily place in the care and custody of these men their lives and property, to do everything within their power to make them the best, safest, most efficient men possible; and in doing this, in my opinion, no agency can be enlisted so adapted, so consecrated, so devoted to the work and so successful in the work as the railroad department of the Young Men's Christian Association."

In answer to a suggestion made to President Cassatt that part of the valuable room set aside in the new terminal station of the Pennsylvania Railroad in Manhattan be used for purposes other than Association work, he said, and with emphasis admitting of no further discussion, "That has all been settled." The inference is unmistakable that Mr. Cassatt, in common with many other presidents and lesser officials, considers the railroad department an essential feature of railroad equipment, and space or buildings worth thousands of dollars are well devoted to the work.

These instances attest in no uncertain tones the estimate which railroad officials place upon the value of the work the Association is doing for railroad men.

But if anything further were needed as an evidence of the attitude and appreciation of the railroad companies themselves, it could be found in the record of the large sums of money that every year are being appropriated for new buildings, equipment and maintenance, by boards of directors of railroads all over the country.

A further indorsement of the Railroad Association work comes from the Panama Canal Commission. With the approval of President Roosevelt and the Secretary of War it has been decided to turn over to the railroad department of the International Committee, for operation, the eight clubhouses which the Government is constructing in the Canal Zone for its employes, and carry the salaries of the secretaries on the Government payroll. During his present visit the President has promised to look into the work among the five thousand railroad men employed there in connection with the construction of the canal. Here we have official recognition of the value and efficiency of the work from the highest possible source and character.

But what of the attitude of the men themselves? Does not the immense army enrolled as members answer that question? But their estimate of its value can be no more eloquently at-

* From an address before the Bedford Branch, Brooklyn, N. Y.
† Secretary of the Long Island Railroad.

tested than by stating that they voluntarily contribute 65 per cent. of the cost of operation as against 40 per cent. ten years ago.

It may be suggested that this is a purely economic test; but as another has said far better than I can say it, "After all, the economic test is a fair one. Religion and education have a commercial value. Increase of knowledge, skill and morality always result in increase of earning capacity. Gifts come to the association from those who consider only that it is good business. The result attained satisfies the business sense and the subscriptions come pouring in. If a church or a religious order does not contribute to the economic welfare of a community it ought to go. If it is non-productive from a business standpoint it is because it is non-productive from a religious point of view. The development of conscience is a direct addition to wealth."

As a closing word let me say that splendid as have been the results achieved by the instigators of the movement and those who have carried on the work of the railroad department from its inception to the present time, so pregnant with glorious possibilities seems the future, that it is no idle prophecy to declare it to be as yet only in its infancy. God grant there may be no diminution of interest on the part of the employer or employee in the efforts being put forth by the railroad department of the Y. M. C. A. for the betterment, physically, mentally and spiritually, of all sorts and conditions of railroad men throughout the world.

STEEL PASSENGER CARS.*

By J. F. MacEnulty.

The development of all-steel passenger cars has been much slower than steel freight cars; presumably for the reason that steel freight cars were the outcome of a desire to carry a greater load and not increase the dead weight, a little experience having taught that 80,000 lbs. or over was too great a continual loading for a wooden car. The fact of fewer repairs and less damage in wrecks is a potent argument, and used much by steel car builders and agreed to by railway men, but had there not been so great a demand for increased loads the steel freight car pioneers would have had a sorry time.

In passenger construction the question is different. There are not the same increased loads to carry per car. If there are more passengers it means more cars. It is true that present passenger coaches are somewhat longer and much heavier, and will resist impacts that would have wrecked cars built ten or fifteen years ago. It is true, also, that they are operated at much higher speeds, and while it may seem a broad statement, our average passenger coach to-day is relatively no stronger than the cars of our forefathers. If this is doubted a perusal of the newspaper reports of a few wrecks in late years will suffice. For high-speed service it is practically essential to use a steel car, if the safety of the passengers is considered. The splinters from the old wooden warships in time of action killed more men than the cannon balls. We have been over the Spanish fleet scare for some years and do not expect any one to fire 13-in. shells at our cars, yet in a collision the conditions are not dissimilar. The force of impact will splinter the sills, posts and side plates, and a passenger caught in the wreckage has not much chance, particularly with the addition of a fire. In the steel car the passengers may suffer contusions, but these are cheaper, from a claim department standpoint, than an amputated limb. Aside from the question of accidents, steel passenger cars should be a good investment. The running repairs are less, the car being out of service a shorter time when going through the renovating process, and the steel surface is easier to finish than the wood and does not require so much care, and with steel freight car experience as a guide the life will be much longer.

The car builders are able to get cost and weight of a steel passenger coach or an interurban car very near that of a wooden car built to the same specifications. This is a decided advantage, as the railways are thus obtaining an absolutely non-combustible construction, of infinitely greater strength combined with longer life, for a small additional outlay.

For street railways and electric service in general the steel car has advantages that cannot be lightly thought of. In the first place, a so-called fireproof barn can be built, and so far as the barn itself is concerned it is, no doubt, fireproof; but unless a separate compartment is provided for each car, which is obviously impracticable, there is great danger of fire losses. In electric, subway or elevated service, where the third-rail system is used, the horror of a conflagration following a collision is eliminated. I am advised by electrical experts (although I do not wish to get into deep water on this phase of it) that in event of the insulation being worn off cables, or a trolley wire or third rail getting in contact with an all-steel car, the circuit breakers would cut out the current as soon as the resistance was overcome, which would be but a few seconds, and, in any event, the passengers would be in no danger of electrocution.

One objection to the early all-steel car was its unsightliness. It resembled a tank, and unsightly rivets and splice plates made a startling and objectionable contrast with the smooth surfaces of the wood car. This objection is obviated in the up-to-date car, as all splices and vertical rows of rivets are covered by hollow mouldings that by sight cannot be distinguished from wood, and advanced methods of construction have made the car more presentable, although the strength is unimpaired. Cars are now constructed of cold-rolled, open-hearth steel plates, pressed, and commercial shapes, while the contour and general appearance of the original wooden cars are maintained.

There is one decided advantage in these methods of construction that cannot be lightly passed over. We all know that while a good commercial grade of open-hearth steel is manufactured to-day, yet occasionally some inferior grade will get by in spite of careful inspection. The pressing operation, hot and cold, is an absolute test, and any steel that is defective in chemical or physical qualities will not hold up under the conditions, and is, of course, rejected.

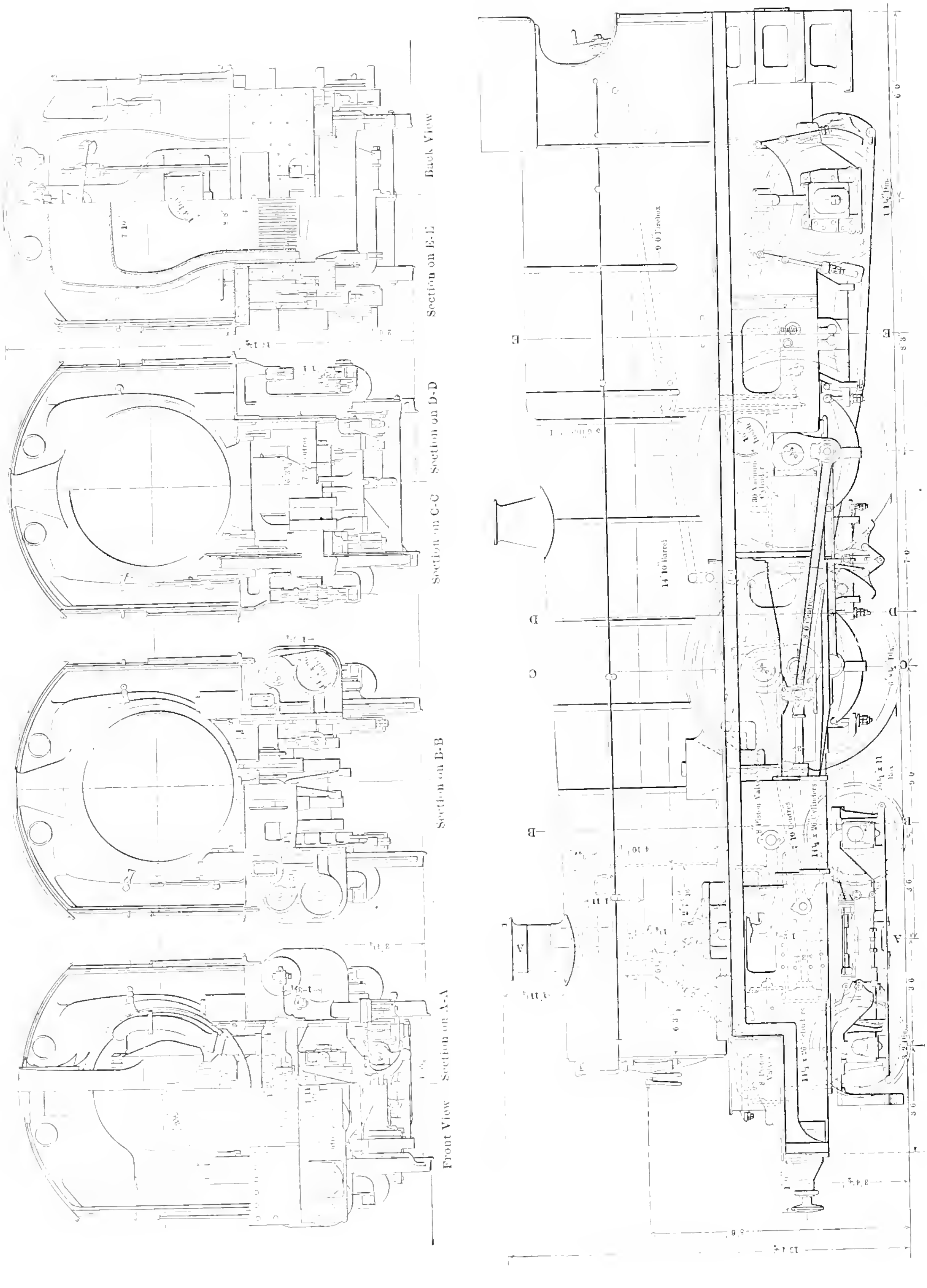
*From a paper presented before the October meeting of the New England Railroad Club.

Weight of Car and Locomotive Wheels Used Per Year.—There are in round numbers one million seven hundred and fifty thousand freight cars, forty thousand passenger cars, forty-five thousand steam locomotives, and eighty thousand electric cars in the United States. The freight cars average eight cast-iron wheels each; the passenger cars, ten; the locomotives, four pilot-wheels, six drivers, and eight tank-wheels; the electric cars average seven wheels each.

This makes a grand total of fifteen million seven hundred and seventy thousand wheels in use in this country on steam or electric roads for the pleasure or profit of the people of the United States. The total weight of these miniature atlases supporting the world of travel is in the neighborhood of five million and sixty-one thousand tons.

The average life of a cast-iron wheel on a freight car is five years, while on all other cars cast-iron lasts only a year. Steel wheels under passenger cars last about five years, and about four years under locomotives, the drivers and pilot and tank wheels having about the same lease of life.

This means that next year the railroads will buy about eighty-three thousand five hundred drivers, one hundred and sixty-seven thousand five hundred steel and steel-tired wheels, and five million three hundred and eight thousand cast-iron wheels. This is allowing also for the normal increase in number of cars in use. The total weight of iron and steel in the wheels added annually to the rolling stock of the railroads of the United States is one million eight hundred and four thousand three hundred and fifty tons.—*Exchange.*



ELEVATION AND SECTIONS OF FOUR-CYLINDER SIMPLE LOCOMOTIVE—GREAT WESTERN RAILWAY (ENGLAND).

FOUR CYLINDER SIMPLE LOCOMOTIVE—GREAT WESTERN RAILWAY.

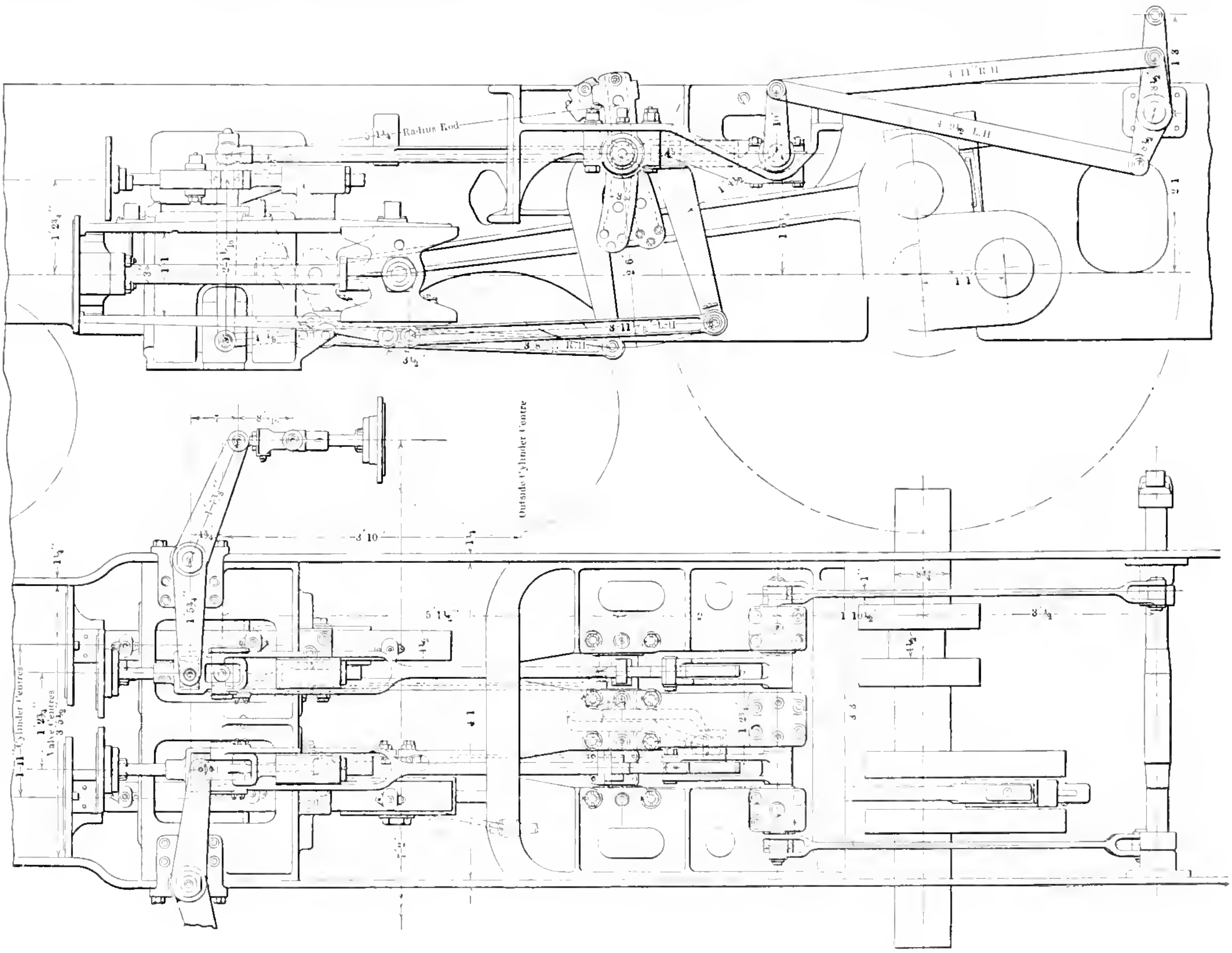
FOUR-CYLINDER SIMPLE LOCOMOTIVE.

Great Western Railway (England).

Mr. G. J. Churchward, locomotive superintendent of the Great Western Railway of England, has recently put into operation an Atlantic type locomotive equipped with four simple cylinders, which, by his courtesy, we are able to illustrate herewith.

This locomotive was designed and built at the Swindon works of the railway and weighs 166,880 lbs. total, of which 88,704 lbs. is on drivers. The tractive effort at 85 per cent. boiler pressure by the Master Mechanics formula is 25,086 lbs. The locomotive has been operating the Plymouth Limited express of the railway and we understand the results of this operation have led Mr. Churchward to prepare designs for some 10-wheel locomotives, which will be of the same design as the Atlantic type in every respect except such minor changes as will be necessary for the addition of the extra driving wheel in place of the trailer. It is planned to have one or more of these new locomotives equipped with superheaters. It is stated that this decision to change the design to a 4-6-0 type was caused by the lack of sufficient adhesion on the Atlantic type for the heavy service demanded. An inspection of the ratios given in the table of dimensions will show the factor of adhesion to be but 3.7, which would seem to be very low and apparently has proven to be so.

In the general arrangement of cylinders and connections this locomotive follows the DeGlehn compound, *i. e.*, the two outside cylinders are set back of the smoke box and connect to the rear pair of drivers, while the inside cylinders are set forward between the frames and connect to the forward pair

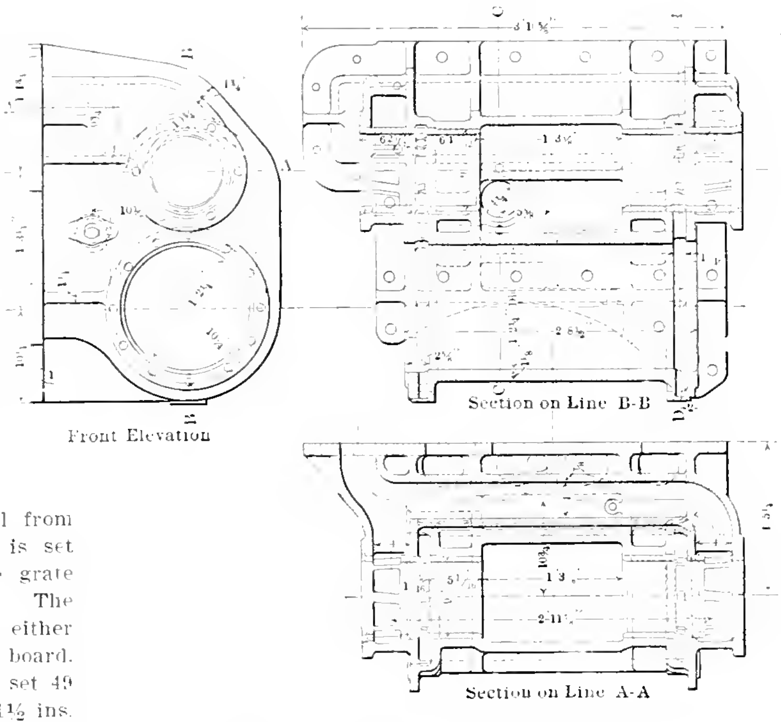


VALVE GEAR, FOUR CYLINDER SIMPLE LOCOMOTIVE—GREAT WESTERN RAILWAY.

of drivers, which have a cranked axle.

The cylinders are all 14¼ ins. in diameter and have a 26 in. stroke, making them equivalent in power to a 20.15 in. cylinder on a two-cylinder locomotive. In area of cylinder walls, however, the two cylinders on one side of course give a much greater surface than a single cylinder of equivalent power.

Outside of the cylinders and valve gear the design follows the typical English construction. The boiler is of the Belpaire type 58¾ ins. in diameter at the front end and 66 ins. in diameter at the fire box connection. It has 250-2 in. flues, each being 15 ft. 2 5-16 ins. long. The pressure is 225 lbs., which is standard on that road for all kinds of passenger power. The grate area of 27 sq. ft. seems small when compared with American practice and its ratio to the total heating surface, which is about 1 to 79, would indicate that either the coal is burned at a higher rate per sq. ft. of grate area in England than in this country or that not as much evaporation is expected from each square foot of heating surface. The fire box is set between the frames and the forward section of the grate has a very decided slope, giving a very deep throat. The dampers are arranged just below the mud ring on either side and are operated by a screw from the running board. The frames are of plate design 1¼ ins. thick and are set 49 ins. apart up to the smoke box where they narrow to 41½ ins. They are very securely and stiffly cross braced at many points throughout the length.



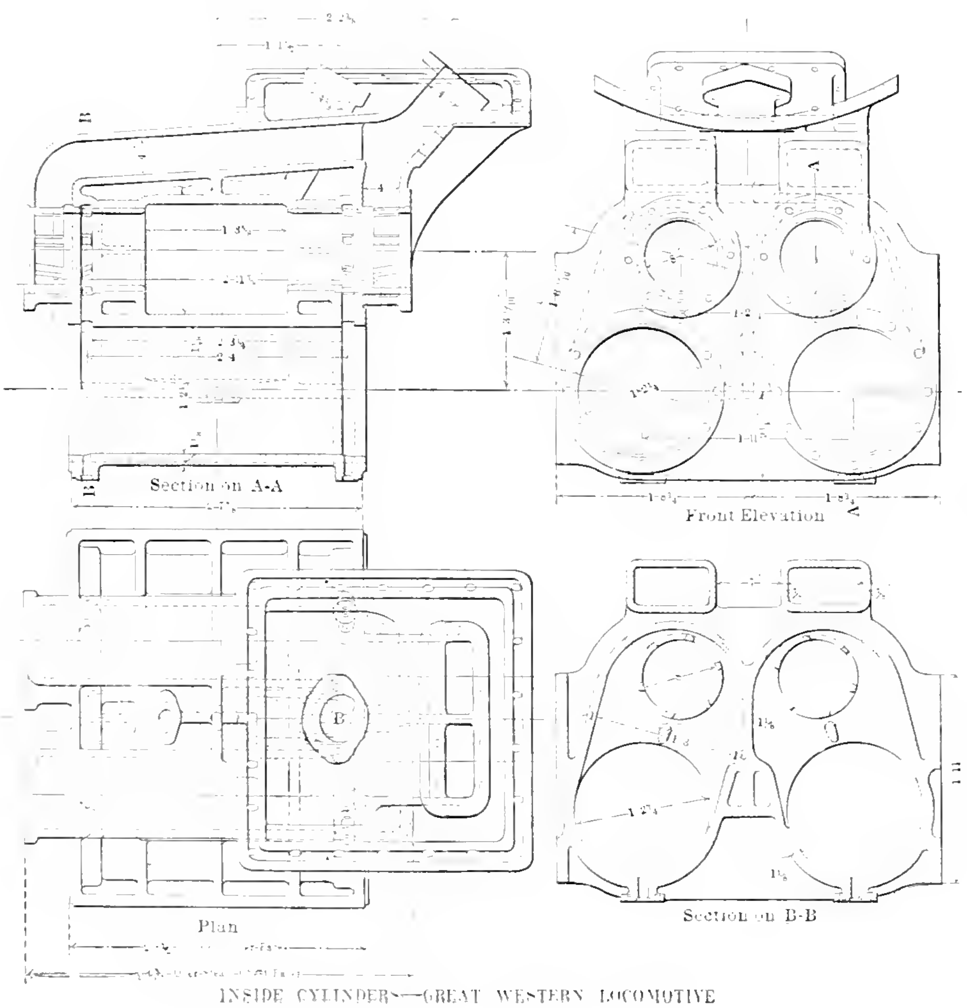
OUTSIDE CYLINDERS—GREAT WESTERN LOCOMOTIVE.

The driving wheels are 80½ ins. in diameter and the drivers and trailers on each side are equalized together, there being no cross equalizer at the trailer wheels. The braking mechanism is connected to a 30-in. vacuum cylinder located between the frames just ahead of the rear driving axle. It is connected to the driver brakes through a cross beam connecting to a toggle joint at the lower end of the hangers and to the trailer by long brake rods.

The two inside cylinders are in a single casting, which also includes the smoke box saddle. The centre of the cylinders, however, is some considerable distance ahead of the centre of the saddle, as is shown in the detailed illustration. The outside cylinders are in separate castings with their valve chambers and are secured outside of the frames. The steam and exhaust connections for the different cylinders are shown quite clearly in the general elevation. From the T head in the front end two steam pipes lead out and down on either side to just below the centre of the boiler where they branch, one part going to the inside valve chest on that side of the engine and the other to the outside valve chest, the connection in the former case being made directly to the top of the valve chest and in the latter through a separate pipe to the inside of the valve chest, passing through the frame. The exhaust passage is similar in arrangement, and branches from each valve chamber joint to a single nozzle.

The valves on all cylinders are 8-in. piston of extra length, allowing the passages to the cylinders to be practically straight. Steam is admitted on the inside and exhausted on the outside, the exhaust passage being an extension of the valve chamber, as is shown in the detail drawing.

The valve gear, of the Walschaert type, has been very simply and carefully arranged. One set of connections operates the two valves on the inside and outside cylinders on that



INSIDE CYLINDERS—GREAT WESTERN LOCOMOTIVE

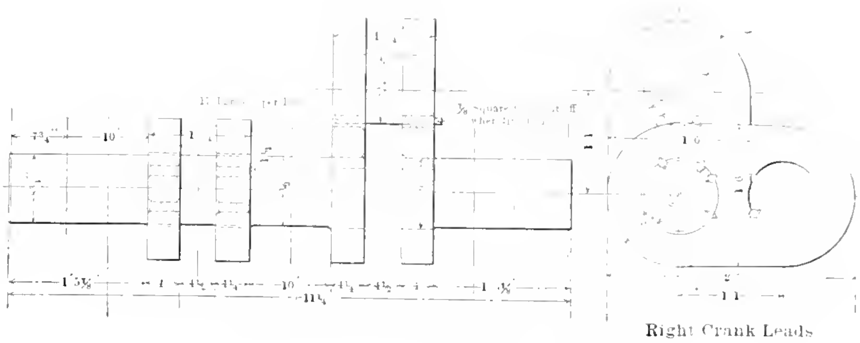
side of the locomotive. Since the inside and outside cylinders are connected at 180 degs., and the steam distribution is the same in both cylinders, the two valves move in direct opposition to each other, and hence by connecting them through a cross lever having equal arms and fulcrumed on the frame, it is possible to operate one from the other. Thus the inside valve only is connected directly to the valve gear, and operates the outside valve through a cross lever having a crosshead connection on the inside and a jointed connection to the outside valve stem. The inside cylinders are connected at an angle of 90 deg. with each other, and so, instead of taking the motion for the valve gear from an eccentric or return crank on the axle, it has been connected to the crosshead of the opposite inside cylinder. Thus there is, on each crosshead, a connection to its own combination lever, and also a connection through a rod extending back and operating the link for the valve motion of the other side of the locomotive. This method of connecting, as will be noticed, makes what corresponds to a return crank for the usual type of valve motion following the main pin in one case and preceding it in the other, and hence it reverses the position of the block in the link for the go-ahead motion in the two cases, *i. e.*, the left hand link block is at the top of its link for the go-ahead motion while the right hand block is at the bottom. This difference in reversing positions is accomplished from one reversing mechanism by having two auxiliary lift shafts operated from arms on the opposite side of the main lift shaft, which is connected directly to the screw reversing mechanism.

The crank shaft is of built-up design in nine pieces, as shown in the illustration, the sections being secured by 1¼-in. screw keys.

The tank is carried on three pairs of wheels, as is quite common in England, and has a capacity of 3,500 gallons of water.

The general dimensions, weights and ratios are as follows:

GENERAL DATA	
Gauge	4 ft. 8½ ins.
Service	Passenger
Fuel	Bituminous Coal
Tractive effort	25,086 lbs.
Weight in working order	166,880 lbs.
Weight on drivers	88,704 lbs.
Weight on leading truck	40,096 lbs.
Weight on trailing truck	38,080 lbs.
Weight of engine and tender in working order	256,480 lbs.
Wheel base, driving	7 ft.
Wheel base, total	27 ft. 9 in.
Wheel base, engine and tender	53 ft. 6¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	3.7
Total weight ÷ tractive effort	6.64
Tractive effort x diam. drivers ÷ heating surface	943
Total heating surface ÷ grate area	78.8
Firebox heating surface ÷ total heating surface, per cent	7.2
Weight on drivers ÷ total heating surface	41.4
Total weight ÷ total heating surface	78.
Volume four cylinders	9.6 cu. ft.
Total heating surface ÷ vol. cylinders	222.
Grate area ÷ vol. cylinders	2.82
CYLINDERS.	
Number	4
Kind	Simple
Diameter and stroke	14¼ x 26 in.
VALVES.	
Kind	Piston
Diameter	8 in.
Steam ports	1¼ x 25 in.
Exhaust ports	3 x 25 in.
WHEELS.	
Driving, diameter over tires	80½ in.
Engine truck wheels, diameter	38 in.
Trailing truck wheels, diameter	49½ in.
BOILER.	
Style	Belpaire
Working pressure	225 lbs.
Outside diameter of first ring	58¾ in.
Firebox, length and width	98 7-16 x 38⅝ in.
Tubes, number and outside diameter	250—2 in.
Tubes, length	15 ft. 2 5-16 in.
Heating surface, tubes	1,988.65 sq. ft.
Heating surface, firebox	154.26 sq. ft.
Heating surface, total	2,142.91 sq. ft.
Grate area	27.07 sq. ft.
Center of boiler above rail	98 in.
TENDER.	
Weight empty	40,880 lbs.
Water capacity	3,500 gals.



CRANK AXLE—GREAT WESTERN LOCOMOTIVE.

Four-cylinder simple locomotives have been described in this journal as follows:

Belgium State Railways, 4-6-0 type with superheater, June, 1906, page 217.

Lake Shore & Michigan Southern Railway, 4-4-0 type inspection locomotive, August, 1906, page 291.

DEMAND FOR MACHINE TOOLS.—Speaking of the constant influx of orders each day which are continually extending deliveries, one of the important interests states that builders of standard tools already have so much work on hand that very few orders placed at the present time can be filled before next year. Of course, a machine can be secured here and there for several months' delivery, but it is a difficult matter to obtain a fair sized shop equipment. This condition of the market has caused prices to stiffen, and those who can promise reasonable delivery on a machine can get a substantial premium, so eager are buyers for equipment. The recent sale of the equipment of the W. S. Burn Manufacturing Company, New Haven, Conn., plainly illustrates the demand for machine tools and the prices that can be obtained for second-hand machinery. There were 547 lots sold at auction in 330 minutes, and the prices paid were in many cases higher than those for new tools. A Bath grinder bought four years ago brought $100 more than the amount paid for it at that time, and Pratt & Whitney lathes brought considerably more than the list price.—*Iron Age.*

CHANGES IN MACHINE TOOL DESIGN.—Manufacturers who would develop radically new designs are so busy filling orders for regular stock that they have little time or opportunity for developing new designs to the extent of manufacture. Many of them, we are assured, have laid out interesting departures, which they are "holding up their sleeves" for the time when business shall slack off and give them a breathing spell. It is a well-known fact that ingenuity in machine tool design, as well as in practically all other branches of machine design, is displayed to the best advantage at the time when business is dull. It is poor policy for a manufacturer to stop a profitable output simply to introduce a new idea. His customers want standard tools and want them at once. The time for experimenting is when things are slow, and we shall probably not see many radical departures from present accepted designs until that time.—*Machinery.*

MANUFACTURING IN THE UNITED STATES.—The manufactories in the United States, which turned out in 1900 $13,000,000,000 worth of products, this being then a record, have increased their output in the short period intervening more than 50 per cent., and it is calculated that their entire production for the year just closed is $18,500,000,000.—*Mr. Charles H. Cochrane, in the New York Herald.*

WIND PRESSURE ON BUILDINGS.—A wind pressure of 30 lbs. per sq. ft. is called for in the New York Building Laws, for buildings more than 100 ft. high, with an allowable unit stress of 50 per cent. more than for dead or live loads. Fowler gives 20 lbs. for buildings less than 20 ft. high and 30 lbs. for buildings 60 ft. high, with no extra allowable unit stress.—*American Machinist.*

(Established 1832).

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Within a comparatively short time it is quite probable that the majority of the new passenger coaches built in this country will be constructed of steel. There are several reasons why this can be looked for, not the least of which is the very large number of passengers killed in recent railway wrecks, many of them by fire. A decided movement in this direction is just beginning, and while at present there are but three all-steel passenger coaches in operation, these are sufficient to show that such construction is practical, and that steel cars can be built of the same size, arrangement and comfort that is found in the modern passenger coach. Such cars can be built to weigh but little more per seated passenger than the wooden cars, and in some cases may even weigh less. At the same time they offer many times the resistance in collision and are fireproof and non-collapsible. The Harriman Lines' coach shown in our January issue weighs 107,000 lbs. and seats 70 passengers, giving a weight of 1,530 lbs. per passenger. The Long Island coach shown in this issue weighs but 1,300 lbs. per seated passenger, this weight including a 5,000-lb. storage battery equipment. The Pennsylvania Railroad has an all-steel coach in operation, which was designed and built at Altoona, and weighs 1,438 lbs. per seated passenger. This weight also includes a 5,000-lb. storage battery, as well as a copper roof, deafening floor and the P. R. R. heating and ventilating system, which are not on the other cars. It is possible to build a coach of greater length, say 70 ft., of the same design which, because of its increased seating capacity, would weigh less than 1,300 lbs. per passenger. These weights can, no doubt, be further reduced after longer experience, and in the case of large orders, where specially designed appliances can be used, the final result being a train which will weigh but little more than the present passenger train, and in view of the rapidly increasing price of lumber will probably cost but little more but will be many times as safe for the passengers.

The balancing of high-speed locomotives by the use of four cylinders connected on the quarters is undoubtedly a good thing for the locomotive and for the track, and in spite of the increased complication making it somewhat unpopular from the roundhouse and shop standpoint, it is being very generally favored in all parts of the world where progressive locomotive designers are found. Up to a comparatively recent time the balanced principle has always been employed in connection with compounding, as was quite natural, since both designs require four cylinders, and the economy to be obtained from compounding was what was chiefly desired, the advantage of the balancing being largely incidental. Recently, however, there has appeared in foreign countries several designs of locomotives which have four simple cylinders connected on the balanced principle. In this country so far but one locomotive of this kind has been built. This movement would seem to indicate that the compound is not proving to be of any great value for high-speed work under the conditions found in certain parts of England and the Continent, although it is considered with great favor in France and on certain railways in other countries; and that in these cases there is a distinct desire to retain simple cylinders while still obtaining the advantage of a balanced locomotive.

It will be remembered that one of the conclusions from the tests on the Pennsylvania Testing Plant was that, "it appears that the relative advantages to be derived from the use of the compound diminish as the speed is increased." However, since the only simple locomotives tested were two freight engines, this conclusion may not apply with equal force to passenger locomotives. We will know more about it upon the publication of the tests now being made on a simple high-speed locomotive.

From an economical point of view the four-cylinder simple as compared with the two-cylinder simple would seem to be at a very decided disadvantage, because of the largely increased area of cylinder walls, ports, steam chests, etc., all of which cause condensation, with its large loss in economy. There is also a greater number of bearing surfaces and mov-

ing parts, all of which absorb power. In the matter of condensation, which is by far the more important, there is a ready remedy in the shape of superheated steam, which also is peculiarly suited for high-speed work and tortuous passages. If the four-cylinder simple is going to compete with the four-cylinder compound in economy, it would seem to be positively essential that it use superheated steam.

If you discharge 10 per cent. of the least efficient men in your shop, or office, how much would you increase the efficiency of your force? Do you know just who the most inefficient men on your payroll are? If one of your subordinates should be promoted, or leave the service, who would you put in his place? How do you select men for promotion? These are rather pointed questions, but the success of an executive officer depends very largely on how he answers them. As we have said many times in these columns, it is far more important to have a good organization than a good equipment.

* * * * * *

A betterment engineer is responsible for the statement that if the 10 least efficient men out of every hundred in a shop, or organization, were eliminated, not only would the output not suffer, but the quality of the work would be better. His idea was that the influence of the poor men upon the others was such that the total output was decreased rather than increased by their presence. It is quite possible that the above result might be gained under the direction of a good organizer, in connection with improving the organization; at any rate, the efficiency of the shop as a whole would be raised considerably, and the statement is at least worthy of careful study.

* * * * * *

The difficulty is to build up and maintain an organization by which it is possible to determine definitely the efficiency of each man in the force, whether in the shop, in the office, or on the road. It would appear that this can only be done when each man has a definite amount of work arranged for him for each working day, and his efficiency can thus easily be determined, depending on whether he does less than or exceeds the required amount of work for a given time. Such a system would, of course, require an entirely different organization from that now existing in most shops, but if as the result of reorganizing and installing a more scientific supervision the exact efficiency of each man could be determined, the result would surely be worth striving for. In one instance where this was done the efficiency of the men was found to vary from 19 to 175 per cent. It does not require a very great imagination to see a greatly increased output in the shop, both in the amount and quality, if the men averaging, say, less than 75 or 80 per cent. in efficiency were discharged and replaced by men of average efficiency.

* * * * * *

It is quite possible that when you have read thus far you will lean back in your chair, smile a peculiar smile and then —dismiss the subject from your thoughts. Your predecessor of 10 or 15 years ago would probably have done the same thing if he had been told what he would be doing if he held your position to-day. Brigadier-General Murray, in addressing the members of the American Society of Mechanical Engineers on their recent visit to the Sandy Hook Proving Grounds, is reported to have said that five years ago the best results that could be attained with a 12-in. gun was one shot in three minutes, and the percentage of hits was 50 at a range of 4,000 to 4,500 yards. During the past year, however, more than one-half of the guns fired made a record of 100 per cent. in hits, the range being increased to 7,000 yards, and the average time between hits being reduced to less than one-half a minute. Judging from the results which have been obtained in different departments of the motive power department on three or four railroads during the past two or three years, it is not saying too much to predict that it would be possible to make almost as great a relative showing, as that made by the 12-in. gun, in the motive power departments of our railroads within the next few years. Such results, important as they may be to our railroads, especially at the present time, will not be obtained without the hearty co-operation and support of the higher officials. Neither can they be obtained if when a man makes an especially good showing on a railroad the railroads allow commercial concerns to step in and take him away from them. Surely a good man is just as valuable on a railroad as in a commercial organization. Why not pay him for it and keep him?

In the discussion on Mr. Paul R. Brooks' paper before the December meeting of the New York Railroad Club on "Railroading from a Business Point of View," some of the "unbusinesslike" proceedings in ordinary railroad life were alluded to. The general practice of cutting down requisitions—perhaps conscientiously made out—by the "man higher up" was referred to, and also the little actual knowledge of the cost of train operation by railroad officials generally. While every manufacturer knows closely the cost of the goods he is selling, it is a fact that railroads have little definite information regarding the various individual items of expense, when by definite is meant the actual expenditure per unit of work accomplished. It is true that we can divide the total figures of any one account by the engine mileage, train mileage, ton mileage, or any other factor and obtain a unit cost for the system or division, but this will not differentiate the uphill and level work, or the slow and time freights, nor can we gather any idea of the cost per horse power developed per hour, nor the factors of grade, speed, loading, etc.

We can further make comparisons between the monthly performances of locomotives in order to determine whether the coal consumption per engine or ton-mile is increasing or diminishing, but if it be increasing it is often difficult to assign a reason for it, although a perfectly logical one may exist.

The application and study required to obtain an accurate knowledge of these costs have, no doubt, been the reasons for ignoring this interesting and instructive subject, but when we consider the vast sums expended annually in producing transportation, it is evident that such studies would be extremely remunerative to the railroad companies. Some speeds and loading will cost more than others, and for this reason there must be a certain combination that will produce transportation at a minimum cost, but the discovery of this minimum cannot be made without much time and trouble. The variables are many and vary according to different laws, and each division of a road must be worked out to suit its characteristics and equipment, but when this is done the results are not uncertain.

The recent work by Mr. G. R. Henderson on the "Cost of Locomotive Operation" is the only treatise that we know of which goes into all the details of this important question, and in a plain and straightforward manner describes the methods of determining these costs. He considers the value and economical use of fuel, water, lubricants, tools, etc., as well as the cost of renewals, repairs, engineers, firemen, hostling and turning, cleaning fires, wiping, inspecting, firing up and calling, and gives various illustrations of the method of applying these data to the important question of the determination of minimum cost and maximum output.

These will very often demonstrate the fallacy of the claimed economy of the maximum train load under which a locomotive can stagger and prove that in many cases maximum output and minimum cost can both be obtained by judicious arrangement of load and speed. Mr. Henderson has had a wide experience in motive power work and engine rating in various parts of the country, and he is well qualified to interpret and discuss this question from both a theoretical and a practical point of view. We know of no work that gives as much valuable information of this kind as can be found in "Cost of Locomotive Operation," and the prospect of legislation for reducing hours of train men will make this subject still more important. If such legislation is passed and operating costs can still be maintained at a low figure by properly studying the question, the anticipated law will not be necessarily dreaded.

INSTRUCTIONS ON FIRING LOCOMOTIVES.

The following instructions to govern the firing of locomotives for the suppression of dense smoke have been put into force on the Baltimore & Ohio Railroad by Mr. J. E. Muhlfeld, general superintendent of motive power:

Engineers will be responsible for the proper operation of locomotives with respect to the handling of the reverse and throttle levers, and the supplying of feed water.

Engineers and firemen will be equally responsible for the operation of the steam blowers or smoke suppressors and for the smokeless and economical method of firing locomotives, in accordance with the following general instructions:

Before the commencement of a trip or day's work the rocking and drop gates, ash pan dampers, ash pan slides and steam jets, and grate and ash pan operating gear should be examined and tested to see that all grates set level when latched and that all parts are in good working order and in proper position. The smokebox and ash pan should be clean and the smokestack and ash pan steam blowers in good order. All necessary fire tools must be on the locomotive. The fire must be put in good condition on the grates by spreading and replenishing with fresh fuel, in small quantities at a time, until properly built up preparatory to starting with a full supply of water and steam in the boiler. The coal on the tender should be wet down.

Lumps of coal should be broken to as near the size of a man's fist as consistent before putting into the firebox.

A thin, clean fire should be maintained so that the fuel can be supplied with sufficient air through the grates for proper combustion, and produce a clear bright flame. Cross firing should be practiced to maintain an even bed, free from holes, and localized heavy or lumpy firing should be avoided as the latter method does not permit sufficient air to pass through the fuel and results in dense smoke and clinkers. The use of the rake and "puddling" of the fire should be resorted to only when absolutely necessary to spread an uneven fire caused by uneven draft or improper firing. The banking of green fuel at the furnace doors should be restricted.

The grates should be kept well supplied with coal at the sides, ends and corners of the firebox, and not more than two or three shovelfuls, each scattering the coal, should be supplied at one time. Heavy intermittent firing should be avoided. Only sufficient fire should be kept on the grates as is necessary to prevent loss of heat on account of cold air passing through the grates so freely as to reduce the temperature of the gases, and to suit the way the locomotive is being operated.

Injectors and reverse and throttle levers should be operated to favor the firing when starting from a station and on heavy pulls. The smokestack blower should be used when necessary to prevent reduction in boiler pressure, and the boiler feed should be increased to prevent release of steam through the pop valves.

Previous to the closing of the throttle valves, the fireman should apply the steam blower or smoke suppressor to such an extent as practice may demonstrate is necessary to suppress smoke. When locomotives are working steam, the smoke suppressor should be used lightly. The supply of steam to the air induction jets should be regulated by the size of the opening in gasket, so that on locomotives not equipped with brick arches there will be no tendency to blow the smoke to or through the flues.

Rocking grates must be shaken lightly and frequently, instead of violently at long intermittent periods, and, if possible, when the steam is shut off. As a general rule, all rocking grates on passenger locomotives should be shaken every 30 miles, on freight locomotives every 15 miles, and on switching locomotives every three hours. This practice will break any clinker that may be forming over or hardening between the grate openings, and will allow dead ashes to fall into the ash pans and keep the grates and fire clean. It will also allow air to pass through the grates and fire, and prevent the formation of clinker on the firebox flue and crown sheets, which occurs when air cannot get through the grates and must pass over the fire.

The practice of opening the furnace door unnecessarily should be avoided, and firemen must regulate the ash pan damper openings to suit the requirements. When locomotives are drifting the fires must be maintained in a clean and bright condition over the entire grate area, more especially at the flue sheet.

Hopper sides of ash pans must not be opened when the locomotive is running. Ash pans and fires should not be cleaned near any frog, switch, crossing, de-rail or wooden building or structure.

Certain fuels and locomotives will require special treatment, but in general the above methods are those of the most successful firemen, and the highest type of fireman is one who can maintain the working steam pressure within a range of ten pounds variation with the smallest amount of fuel and the least waste of steam through the pop valves.

Exhaust nozzle openings and draft appliances must be adjusted to suit the winter and summer conditions, and when necessary on account of change in quality or kind of fuel furnished.

Engineers must immediately report any irregularities in connection with the cleaning or building of fires at terminals. They must also report defects in connection with piston or slide valves; cylinder, or rod packing; dry, steam and exhaust pipes; smokebox draft appliances; stopped up, or leaky flues; rocking and drop grates, ash pans and dampers; smokestack and ash pan, steam blowers and smoke suppressors; and all other auxiliary equipment pertaining to the economical use of steam and fuel, and for the prevention of dense smoke. All adjustments or repairs that may be found necessary must be promptly and properly made.

The company has been and is now expending a considerable amount of money to put machinery, boilers, fireboxes, flues, grates, ash pans, and draft appliances of locomotives in a substantial condition for service, and with the grade and quality of fuel supplied, it is expected that some returns in fuel economy through proper methods will result from the operation and firing of locomotives. Passengers and the public at large are also entitled to consideration, and the elimination of dense smoke will contribute to their comfort, as well as to reduced steam failures and waste of fuel.

Master mechanics and road foremen will see that these instructions are complied with.

Common Sense in Drafting.—Drafting, like mathematics, is only a means to an end, and a man who makes his drawings as if they were the goal instead of a part of the course is likely to put a pile of work into them which is really useless. The sun may always shine from the upper left-hand corner at the Patent Office, and shade lines are well worth all the extra time they take on a good many jobs, but a fair amount of common sense is better than too many rules and regulations in a drafting room as well as outside of it.—*E. R. Plaisted, in Machinery.*

Expert Knowledge Not Executive Ability.—Either a man is competent to be put in entire charge of a department or plant, or he is not. If he is, let him run it himself. If not, you must run it for him. When subordinates are being appointed, expert special knowledge is frequently mistaken for executive ability. This throws the real load, the work of thinking, upon his superior.—*Paul R. Brooks, before the New York Railroad Club.*

Good Engineering.—In the "One Horse Shay," Dr. Oliver Wendell Holmes, as well as the good deacon, builded better than he knew; for it should not be considered merely as a logical triumph, but as an ideal of the accuracy of engineering calculations in correctly estimating the strength of each part, and exactly providing for the depreciation of the whole work —*Mr. C. J. H. Woodbury.*

BETTERMENT WORK ON THE SANTA FE.

To the Editor:

While your December issue presented a very full and most interesting article on the process of industrializing the Santa Fe mechanical department, yet there are some particulars involved concerning which a little further explanation would seem pertinent. For, in a study of the proposition as set forth in the article, one gains the impression that the innovations have not been confined to the methods of accomplishing the work, but go further and include departures from the usual methods of distributing accounts and exhibiting results. At first sight the results exhibited appear excellent. In fact, they may be enhanced by exhibiting them in this manner:

Year.	Engines owned.	Average tractive effort.	Repair cost per engine mile.	Repair cost per 1,000 lbs. of tractive effort per mile.
			Cents.	Cents.
1903	1,309	22,526	9.97	.4426
1904	1,433	25,578	13.42	.5247
1905	1,454	26,217	14.87	.5710
1906	1,633	27,684	11.08	.4002

The diagrams of mileage per engine failure exhibit a considerable variation between different divisions. Inasmuch as water purification has been undertaken quite extensively on the Santa Fe it would seem pertinent to state what modifying effect these plants had on the results exhibited for the various divisions.

Again, the article shows 1,454 locomotives owned in the year 1905, and 1,447 of these in service. This shows but 7 locomotives not performing service for that year. The annual report, year of 1906, shows 1,633 locomotives owned and but 1,550 in service, or 83 locomotives not performing service. Ten locomotives were sold or broken up in 1905 and 13 in 1906. From the annual reports of the Santa Fe it may be noted that in 1905 no new locomotives were put in service, but in 1906 159 arrived and were put in service. Taking 83 engines out of service as compared with the 7 of the previous year and allowing for the 3 more broken up we have 73 more locomotives out of service in 1906 than in 1905. Was not the keeping out of service of these 73 old locomotives because of the 159 new locomotives of maximum power, together with the extension of water purification, a very considerable factor in reducing the cost of engine repairs from 14.87 to 11.08 cts. per mile, without regard to the factor of shop betterment?

It was stated that in addition to the customary staff of the railway mechanical department a separate general staff of 31 men had been provided in connection with the betterment work. This would imply a still further list of clerks and various special men not mentioned. Yet a study of the annual reports for 1906 shows an increase of but $79,732 over the previous year for the superintendence of the entire mechanical department and the included car department has been specifically excepted from the betterment benefits. Furthermore, that charges to repairs and renewals of shop machinery and tools for the entire department shows $119,146 less than the previous year, and the charges for new shop construction and equipment on existing lines shows but $380,978, or a decrease of $42,654 from the previous year. Yet we find charged to "capital account," for buildings and shops, $1,289,230, or an increase of $567,827 in 1906. Has the betterment expense been charged to this account? Or, has it been included in the $4,500,000 written off the income account for "betterments and improvements"? And were these charges to these accounts necessary because of the exhaustion of the $900,000 special betterment fund which is not mentioned in the annual reports subsequent to 1904?

Without some such distribution of the betterment expense, it is hard to understand the consistently normal costs of superintendence and of repairs and of renewals of shop machinery and tools. And furthermore, if such distribution has not been made it is difficult to account for this sudden great increase of the general accounts mentioned. While, if such distribution has been made, the consequent relief of the maintenance of equipment accounts from the cost of this special betterment work, materially alters the significance of the figures cited as showing the results of the shop betterment work.

One does not wish to appear unduly critical of the working out of a new proposition and this inquiry is merely one expression of the very general interest awakened by Mr. Emerson's work, which prompts a desire for knowledge of the modifications, if any, of such special distributions, without which the accomplishments are somewhat difficult to reconcile with the usual attainments. If there are such modifications it would be both interesting and valuable to know their extent for the use of railway men who may find it necessary to undertake similar reorganizations.

T. S. Reilly.

To the Editor:

Mr. T. S. Reilly's critical questions are pertinent. I am glad of an opportunity of giving the little further explanation for which he is justified in calling.

The criticisms are:

1. That there are departures from the usual methods of distributing accounts.

2. That water purification had modifying effects on engine failures.

3. That the purchase of new power was responsible for much of the improvement.

4. Although Mr. Reilly does not make this criticism it has been pointed out by others that in spite of betterments, locomotive maintenance, as shown by the president's report, is still high on the A., T. & S. F. Ry.

As to 1, there were absolutely no departures from the usual method of distributing accounts. All the expense, material and labor was distributed to the maintenance accounts practically wholly to supervision, locomotive maintenance and tool and machine maintenance. No part of it was included in the capital account, none of it in the $4,500,000 written up, nor any part of it to the special betterment fund.

As to 2, it is suggested that as the various divisions show great variations in improvement, the latter may be due to water purification. While treating plants have undoubtedly lessened engine failures and decreased the cost of repairs, those installed where the water was worst were in operation long before the last fiscal year.

It is unfortunate that these past records have not been tabulated with reference to this particular point, namely, the relation between engine failures due to poor water and water analysis.

Of the grand divisions of the system the one showing the greatest increase in mileage per failure and also showing the greatest mileage per failure is the Gulf and Texas grand division which has no treating plants. The two divisions of the system holding the best records both for improvement and absolutely are the Southern Kansas and the Valley division in California, each a little better than 12,000 miles. Neither of these has any treating plants.

During the fiscal year 10 treating plants were added to a previous total of 58, an increase of 17 per cent.

As to 3, the purchase of new power as a cause of decreased maintenance cost, the annual report shows:

Engines on hand June 30, 1904	1,433
Net engines added	21
Engines on hand June 30, 1905	1,454
Net engines added	179
Engines on hand June 30, 1906	1,633

Engines owned June 30th and engines actually in service during the year are different propositions. It happens that most of the new engines in 1905-6 came into service the latter part of the fiscal year. Reduced to a year basis the added engines amounted to 65. This number added to the previous year's total makes 1,529. The figure used—1,550—is at least 20 engines too high. Beyond the 13 scrapped as against 10 the previous year, small old timers, there were no engines retired. During the year all the shops on the system at one time or another ran short of work and every engine not condemned and scrapped was repaired.

This figure of 1,550 engines for 1906 compared to 1,447 in 1905 is the average of all locomotives owned during the year and has no reference to service. There were therefore no 79 engines out of service and only the equivalent of 52 new engines in service.

Unfortunately compound engines carrying 220 lbs. of steam, of new design and advanced type and burning oil, are not, in the first two years of their life, low in repair cost. Even fire boxes have had to be renewed on some of them. There have been other expensive repairs, consisting largely in the strengthening and replacing of weak parts. This unusual expense is inherent to any advanced new design, so new engines are not to be credited with the general reductions of maintenance expense on engines. This is not hypothesis, but based on individual engine repair costs covering four years, accounts tabulated as to classes, divisions, shop where repaired, roundhouse or back shop expense, material and labor, etc., etc.

As to 4, it has been further pointed out that even under present conditions engine maintenance costs on the Santa Fe are high, and as proof of this the figures of the president's annual report are quoted. On exactly the same basis as the previous year these

engine expense figures decreased per engine owned $1,064.07. This figure is, of course, valueless as a criterion of actual cost of engine maintenance. If a company doubled its engines and each did only half as much work the cost per engine on the above basis would be cut in two not only without any real improvement but with positive loss since twice the amount of capital would be tied up in engines, roundhouses, etc., and the engines would be fast becoming obsolescent in type. It is the practice on the Santa Fe whenever an old engine is scrapped, even if of the smallest and most antiquated type, to charge the maintenance with the cost of a new modern engine, the figure being, I believe, $18,000.

In making comparison between 1904-5 and 1905-6 it was considered much more instructive to take as a unit engine mileage multiplied by average weight on drivers in lbs. divided by 100,000,000.

	1904-5.	1905-6
Road units	47,855	55,994
COST PER ROAD UNIT OF VARIOUS ACCOUNTS		
Supervision (11)	$7.68	$7.97
Locomotive Maintenance (12)–		
Labor	70.15	48.92
Material	36.77	29.69
Tools and machinery (17)	10.15	6.56
Miscellaneous (19)	17.07	10.08
Total	$141.82	$103.22
Tons of fuel per road unit	58.2	55.6

No one should wish to compare maintenance costs on a mileage basis with other roads whose engine weight is far less or even with the same road when engine weights were considerably less.

It may still be objected that this road unit cost figure is not as correct as if the road unit costs of each separate engine were summarized. This was in fact first done for a period of three years and the annual figures derived from the president's report tallied very closely.

No claim whatever is made that the betterment methods have resulted in bottom figures on the Santa Fe. None better than those connected with the work know how much can still be done. The work in question was almost wholly limited to maintenance accounts, in these accounts to three only, supervision, engines and shop tools, less than half of the whole.

The methods were in full effect only on part of the system and for only a part of the year. Had it been possible to apply them to all accounts on the whole system for a whole year the results would have been otherwise gratifying. As it is, beginning with such an insignificant item as belt maintenance, extending upwards to embrace tool account and then to the engine account, the results are an irrefutable demonstration of the practical value of certain methods as applied to railroad operation.

HARRINGTON EMERSON.

Topeka, Kan.

THE SURCHARGE PROBLEM.

TO THE EDITOR:

Referring to Mr. H. Emerson's communication on page 478 of the December issue: "It requires only a simple mental calculation to show that 80 per cent. of ten men's wages is the same as 160 per cent. of five men's wages, and that the surcharges have not been increased at all." As to the confounding of surcharges with cost Mr. Morrison endeavored to show us that the surcharges are a part of the cost just as much as labor and material, and his excellent article was not written in vain. But let us confine our attention strictly to the example in the October issue, the accuracy of which has been questioned and, to make the case more concrete, let the given article be a particular type of oil can.

Says Mr. Purchasing Agent to Mr. Superintendent of Motive Power, "I can save money for the company by purchasing that can on the market in place of your manufacturing it in the shop I can buy it for $2.50." In the natural course of events it becomes necessary for the shop superintendent to furnish the necessary figures to enable the superintendent of motive power to determine where he is at. The figures submitted (quoted from Mr. Morrison's article) are as follows:

Material	$0.85
Labor	1.25
Surcharge, 40 per cent.	.50
Total	$2.60

There exists no intention to close down the tin shop or any part of it. The problem is simply to determine whether the purchasing agent is right or wrong and to act accordingly. The result of this addition is all right as far as it goes, but it is only part of the problem.

If the 40 per cent. surcharge is not to be loaded on to the remaining work of the tin shop then it must be decided as to what new line of work will take care of it, and let us suppose water buckets are next considered, the market price of which is one dollar. Let the supposed computed cost be as follows:

Material	$0.30
Labor	.60
Surcharge, 40 per cent.	.24
Total	$1.14

If we stop here our calculations show the purchasing agent to be wrong, or if the cost of the bucket figures out to be less than one dollar, the figures say he is right; but the problem is not yet complete.

If the company is using twice as many oil cans as buckets per year it can afford to buy one thousand oil cans and save ten cents per can and manufacture five hundred water buckets and lose fourteen cents per bucket. But if, on the other hand, there is a demand for twice as many buckets as cans then the tin shop had better continue to make oil cans. If the cost of the water bucket is below the market price it must even yet be determined whether or not there will be a sufficient number manufactured to take care of as large a per cent. of the tin shop's total yearly surcharge as before.

There are other items that may be worth consideration; but I believe enough has been said to show that a correct solution "beyond the shadow of a doubt" cannot be obtained by the simple addition of three quantities.

THEO. F. H. ZEALAND.

Illinois Central, Chicago

[Editor's Note.—Mr. Zealand's point is well taken and his letter is reproduced in order to, if possible, bring this matter of the "surcharge problem" more clearly before our readers. Mr. Morrison in his article in our October journal and in a communication in our December issue has very clearly defined this question of "surcharges" and told us exactly how it has been worked out in a large shop. In outlining the method of arriving at the proper surcharge and in considering its application it is quite possible that the impression may have been conveyed, as would appear from Mr. Zealand's letter, that the matter of manufacturing or buying equipment was settled entirely by the result of these figures. There are, of course, many conditions which might arise which would warrant manufacturing a given article when it could be bought on the market at a lower cost. Mr. Morrison's idea was to show the exact method of arriving at the correct cost of an article, assuming that it would be understood that other conditions would of course be taken into consideration in determining whether to buy or manufacture a given article.]

HIGH-SPEED STEELS FOR WOODWORKING.

Builders of woodworking machinery assert that they have demonstrated to their complete satisfaction that the high-speed steels are destined to bring about radical improvements in the woodworking industry, and some even go so far as to prophesy that it will be revolutionized in the near future. The steel has been in use for these purposes for some little time, but in a limited way. Its usefulness has been hampered by a lack of knowledge of its characteristics as applied to the machining of wood, and it was only recently that tests have been concluded which give to the mechanical engineers employed by the builders of woodworking machinery something approaching exact knowledge of how the steel will work under the various conditions of this industry: where its real usefulness lies; the speeds and feeds which may be employed to best advantage; its wearing qualities and their application to cutting edges, and so on into minor details. The tests made by one of the best known and largest of the woodworking machine establishments brought out these general facts:

The rate of feed may be nearly doubled.

The cutting knives keep an edge from 3 to 10 times as long as the old steels.

The knives may be ground with a better edge.

The sharpening of knives may be done to advantage without removing them from the head.

A slower speed of knife head is entirely practicable.

Most interesting, and probably most important of all, is the knowledge that the real value of the new steels in woodwork-

ing lies in the finish given the work. The advantage in roughing out heavy work, or in other heavy duty, is secondary to that of finish. The new steels will do more work than the old, according to these tests, but it is not for this that it will be especially valued, or that it will act as a revolutionary agent, if so great a change in the industry is to be effected. These statements will sound somewhat paradoxical to those who employ the new steels in working metal, where they have been of little or no value in finishing work, though of exceedingly great importance in heavy or rapid reduction. But, according to these tests, in working wood the quality of the steel is such that, to take a test of planing as an example, instead of a succession of knife marks there is a clean, unmarred surface, with a glossiness similar to that obtained in a sanding machine. Sample boards planed at the rate of 105 ft. a minute showed this characteristic, and they included several varieties of both hard and soft woods. It should be noted that 60 ft. a minute is a high rate of feed for planing with the carbon steels.

Probably the reason for this better finish lies in the durability of the steel, which renders it possible to give the knives a keener edge, in the knowledge that it will stand up to the work for a reasonably long time. One occasionally hears of an expert woodworker who, using the ordinary knives, has planed to a finished surface, free of knife marks, but this was under exceptional circumstances, at slow feed, and perhaps with knives specially ground for the purpose. Under the new conditions, according to those who have made the tests, finished surfaces should become the universal practice in planing machines, and this at very high rates of feed. However, it must be remembered that tests are usually made under exceptional conditions, because the operators are working intelligently and even scientifically. The use of the new steel must be worked out into an accepted practice in its treatment of the steel as such, in methods of sharpening, the form of cutting edge, and in other ways that must become general in their acceptance before the steel can be applied successfully in a universal way. This will take some time, but nevertheless the development of the new practice will go on much more rapidly than formerly as soon as the manufacturers of woodworking machinery shall have adopted it as standard.

As to the use of the steel for heavy reduction purposes, there should be an advantage in its use, as in metal, but not to such great extent. The faster feed and the better ability to maintain an edge will count for a great deal, but it should be stated that in the way of rapid reduction the old steels have been entirely satisfactory, and seldom has a task been found beyond the temper of the cutting blades. For special purposes, doubtless, the new steel will be valuable, as, for instance, in the machining of very hard woods. As for the form of the knives, the tool holder is coming into vogue for the purpose, the blades consisting of thin, narrow strips securely clamped to the head.—*The Iron Age.*

CAR AND LOCOMOTIVE OUTPUT IN 1906.

Official returns from the 38 car-building companies on the North American continent (estimating two small plants not heard from), give the total number of railroad cars built during 1906 as 243,670. This includes subway and elevated cars, but does not include electric street and interurban cars. In addition to this total, the railroads have built in their own shops a large number of cars, both freight and passenger, but no estimate has been made of these. Of the manufacturers' output, 240,503 cars were for freight service, and 3,167 for passenger service; 236,451 were for domestic use, and 7,219 for export. Canada built 7,059 freight cars and 83 passenger cars, and Mexico built 203 freight and 6 passenger cars. The increase in the Canadian output over last year is 230 per cent. All of the builders have shared alike in the tremendous increase. A number of the companies reported this year the number of unfilled orders on their books. Most of them have more cars on order than they have built during the entire year with their plants working at their maximum capacity. This is the best indication of the enormous demand for rolling stock and the utter inability of the railroads to get the cars they need. The following table shows the *Railroad Gazette's* compilation of the number of cars built during the last eight years; totals for 1905 and 1906, including Canada:

Year.	Freight.	Passenger.	Total.
1899	119,886	1,305	121,191
1900	115,631	1,636	117,267
1901	136,950	2,055	139,005
1902	162,599	1,948	164,547
1903	153,195	2,007	155,202
1904	60,806	2,144	62,950
1905	165,455	2,551	168,006
1906	240,503	3,167	243,670

The locomotive output is quite as phenomenal. The 12 builders in the United States and Canada turned out 6,952 locomotives during the year, of which 6,232 were for domestic use and 720 for export. This is an increase of 27.3 per cent. over last year's total of 5,491. These figures do not include locomotives built in railroad shops, or locomotives rebuilt or repaired. There were built 237 electric locomotives and 292 compounds, as against 140 and 177, respectively, last year. The Canadian output was 217. The following table shows the number of locomotives built during the last 15 years; totals for 1905 and 1906, including Canada:

1892	2,012	1897	1,251	1902	4,070
1893	2,011	1898	1,875	1903	5,152
1894	695	1899	2,473	1904	3,441
1895	1,101	1900	3,153	1905	5,491
1896	1,175	1901	3,384	1906	6,952

The cost of cars and locomotives has increased considerably during the year. Estimating the average cost of freight cars at $1,050, the total spent for freight cars amounts to $252,525,000. For passenger cars at $8,000, the cost was $25,336,000, and for locomotives at $14,500, the cost was $101,384,000. The total amount spent by the railroads for new rolling stock and motive power thus approximates $380,000,000, an increase over last year of about 45 per cent.—*Railroad Gazette.*

Overheating High Speed Tools in Grinding.—The writer trusts that he has made the fact clear that the property of "red hardness" in tools is seriously impaired by even temporarily raising their temperature beyond 1,240 deg. F. He ventures to say that fully half of the high-speed tools now in use in the average machine shop have been more or less injured and are therefore lacking in uniformity, owing to their having been overheated during the operation of grinding. Even when a heavy stream of water is thrown upon the nose of the tool throughout the operation of grinding, tools can be readily overheated by forcing the grinding or by allowing the tool to fit against the grindstone. This injury is all the more serious because there is no way of detecting it except by finding through actual use that the tool has become of inferior quality. The writer has frequently seen tools which were ground under a heavy stream of water heated so that the metal close to their cutting edges showed a visible red heat. Occasionally tools are also overheated by running at too high speeds in the lathe. In this case, however, the injury to the tool is perfectly apparent, and therefore not so serious as the overheating on the emery wheel. A tool which has been overheated either in grinding or in the machine can be again rendered first-class in quality by grinding it from 1-16 to 3-16 in. back from the cutting edge and down from the lip surface, because overheating from grinding or running in the lathe rarely penetrates beyond this depth. The best advice that we can give to those desirous of having uniform tools is not to experiment with new brands of tool steel. Adopt once for all the best that can be had at the time the choice is made, and then see to it that the smith heats each tool uniformly and rapidly close to the melting point, and that the grinder does not overheat the tool in sharpening it. Watch the smith and the grinder; do not change the make of the tool steel.—*Mr. Fred. W. Taylor, before the A. S. M. E.*

ALTERING LOCOMOTIVE WHEEL PRESSURES.

W. H. Van Druten, M. E.

It is occasionally found advisable after a locomotive has been in service for some time to make a change in the wheel pressures. This can, of course, be done within limits by a change in the equalizer and spring rigging, but the "cut and try" method often used in doing this is a very slow and tedious process. By the application of a little elementary mathematics the problem becomes simple and exact, as is shown in the following example:

Take, for instance, a 4—6—0 engine, having the following wheel pressures:

On front drivers	53,000 lbs.
On middle drivers	46,000 lbs.
On back drivers	49,200 lbs.
On truck	24,000 lbs.

The last-named weight being too small, as it does not insure sufficient guiding power to the locomotive running through

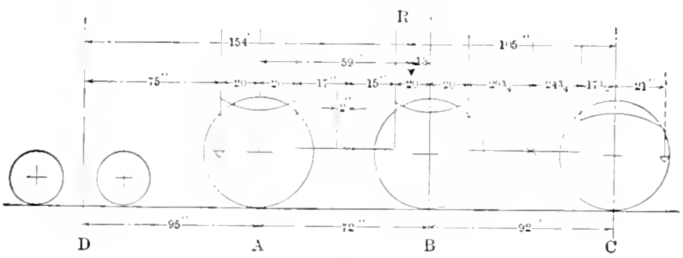


FIG. 1.

curves, it is required to increase this weight by moving the fulcrum of the front equalizer.

Let us move the fulcrum 2 ins. back, making the equalizer arms 17 ins. and 15 ins., respectively, instead of 15 ins. and 17 ins., respectively.

Subtracting from the new wheel pressures the weights of the driving wheels, axles, boxes and also the weight of the truck itself, which are

Front drivers	8,200 lbs.
Middle drivers	10,700 lbs.
Back drivers	8,200 lbs.
Truck	10,000 lbs.

and calling the remaining weights A, B, C and D, respectively, we get the equation, $A+B+C+D=135,100$ .... (1)

Considering the equilibrium of the front equalizer we get

$$\frac{A}{2} \times 17 = \frac{B}{2} \times 15 \text{ or}$$

$$17\,A=15\,B \qquad \ldots\ldots (2)$$

The second equalizer gives the equation

$$29\tfrac{3}{4} \times B\,\frac{1}{2} = 24\tfrac{3}{4} \times \frac{21}{38\tfrac{1}{2}}\,C \qquad \ldots\ldots (3)$$

From the location and size of the weights A, B, C and D before the changing, being, respectively, 44,800 lbs., 35,300 lbs., 41,000 lbs. and 14,000 lbs., we can find the place of the resultant, or, in other words, the place of the vertical line in which the center of gravity of the weight of the engine above drivers and truck is located. This is found to be at R, at the distances from centers of drivers and truck, as shown in the diagram. (The distance of this center of gravity above rail is immaterial here.)

This point being the same before and after the change, it is now possible to form the 4th equation, expressing the condition that the sum of the moments to the left of this point must be equal to the total of the moments to the right, viz.:

$$154D+59\,A=13B+105C \qquad \ldots\ldots (4)$$

From these four equations we can determine the four unknown quantities A, B, C and D, as follows:

From (4) and (1) we solve for A and equalize the expressions:

$$A=\frac{13B+105C-154D}{59}=135100-B-C-D$$

or $13B+105C-154D=7970900-59B-59C-59D$

$72B=7970900-164C+95D$

$B=110707-2.278C+1.32D$

Equalizing this expression to the value of B from (3)

$110707-2.278C+1.32D=0.908C$

$110707+1.32D=3.186C$

$C=34748+0.414D$

Solving A from (1) and (2) and equalizing the expressions

$$A=135,100-B-C-D=\frac{15}{17}B$$

or $2296700-17B-17C-17D=15B$

$2296700-17C-17D=32B$

$71772-.531C-.531D=B$

Putting this equal to the value of B from (3)

$71772-.531C-.531D=0.908C$

or $71772-.531D=1.439C$

$C=49882-.369D$

By equalizing the two values found for C

$34748+.414D=49882-.369D$

from which $D=19,328$ lbs.

Further having found $C=34748+.414D$

we get $C=42,740$ lbs.

From $B=0.908C$ we get $B=38,800$ lbs., and from (2)

$$A=\frac{15}{17}B$$

$A=34,230$ lbs.

Adding now the weights of wheels, axles and boxes to the weights A, B and C, and the weight of the truck to D, we get the new wheel pressures.

On front drivers	34,230+ 8,200=42,430 lbs.
On middle drivers	38,880+10,700=49,500 lbs.
On back drivers	42,740+ 8,200=50,940 lbs.
On truck	19,328+10,000=29,328 lbs.

Comparing these figures with the original wheel pressures, we see that we gain

On truck	29,328—24,000=5,328 lbs.
On middle drivers	49,500—46,000=3,500 lbs.
On back drivers	50,940—49,200=1,740 lbs.
	10,568 lbs.

and lose on the first pair of drivers 53,000—42,430=10,570 lbs.

This gives a better distribution of weights, as there is more weight on truck and on the main drivers. In some cases a slight addition to the weight on the truck may be obtained by lengthening the spring hangers of the front pair of drivers and shortening them on the back pair, which has a tendency to tip the boiler down in front, turning it round its center of gravity. This allows more water to go to the front, lightening it at the same time at the back. Care, of course, must be taken to make the necessary changes in the springs, according to the new loads coming on them.

In a similar way the question of traction increasers may be treated. To illustrate this, take the case of the New York Central 4—4—2 locomotive, quoted by Mr. G. R. Henderson in his book, "Locomotive Operation," on pages 287-291:

This engine has a device for pushing down the back equalizer at a point 5½ ins. ahead of the fulcrum C, so forming a new fulcrum instead. (See Fig. 2.)

Here we have the wheel pressures:

On trailers	38,500 lbs.
On back drivers	47,500 lbs.
On front drivers	47,500 lbs.
On truck	42,500 lbs.

Taking off the weights of wheels, axles and boxes, and that of the truck itself, gives the weights

Above trailers	38,500— 2,500=36,000 lbs.
Above back drivers	47,500— 7,500=40,000 lbs.
Above front drivers	47,500— 7,500=40,000 lbs.
Above truck	42,500—12,500=30,000 lbs.
Total	146,000 lbs.

Calling the new weights above trailers, drivers and truck, after the traction increasers have pushed the equalizer free from the fulcrum C; A, B, B and C, we can write our equations as follows: (the weights above the driving axles being evident-

ly the same, on account of the equal arms of the equalizer between them):

$$A+2B+C=146000 \quad\ldots\ldots\ldots(1)$$

$$\frac{A}{2} \times 39\tfrac{1}{2}=\frac{B}{2} \times 25\tfrac{1}{2} \quad\ldots\ldots\ldots(2)$$

The resultant of the four pressures (above trailers, drivers and truck) we find to be located at R at the distances from the respective centers as noted in the diagram.

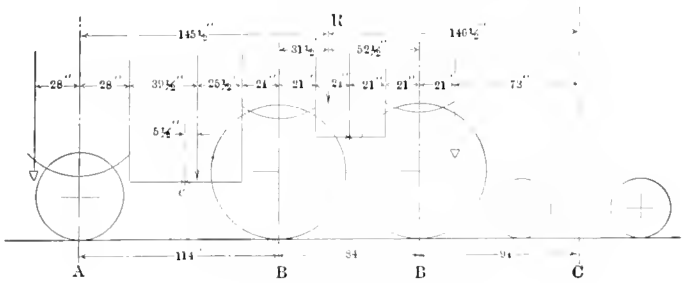


FIG. 2.

This location of the center of gravity not being changed, we have the equation of the moments:

$$145\tfrac{1}{2}A+31\tfrac{1}{2}B=52\tfrac{1}{2}B+146\tfrac{1}{2}C \quad\ldots\ldots\ldots(3)$$

From these three equations we can solve A, B, and C.

Taking the values of A from (3) and (1) and equalizing we get

$$A=\frac{21B+146\tfrac{1}{2}C}{145\tfrac{1}{2}}=146000-2B-C$$

or $21B\times146\tfrac{1}{2}C=21240000-291B-145\tfrac{1}{2}C$
or $312B=21240000-292C$
and $B=68100-.936C$

Taking the value of A from (2) and (1) and equalizing we have:

$$A=\frac{25\tfrac{1}{2}B}{39\tfrac{1}{2}}=146000-2B-C$$

or $25\tfrac{1}{2}B=5766500-79B-39\tfrac{1}{2}C$
or $104\tfrac{1}{2}B=5766500-39\tfrac{1}{2}C$
and $B=55190-.378C$

Equating these two values of B gives

$68100-.936C-=55190-.378C$

from which $C=23{,}130$ lbs.

From $B=68{,}100-0.936C$.

$B=46{,}450$ lbs.

From equation (2) $A=29{,}970$ lbs.

Adding again the weights of axles, wheels and truck, we get the new total wheel pressures.

On trailers	29,970+ 2,500=32,470 lbs.
On back drivers	46,450+ 7,500=53,950 lbs.
On front drivers	46,450+ 7,500=53,950 lbs.
On truck	23,130+12,500=35,630 lbs.

On comparing with the original wheel pressures we find that we gain

On drivers 2 x (53,950—47,500)=2 x 6,450=12,900 lbs.

and we lose on front truck

42,500—35,630=6,870 lbs.

and on trailers:

39,500—32,470=6,030 lbs.

Total.......12,900 lbs.

By this method questions of changes in equalizer and spring riggings become very simple, and much time and inconvenience will be saved by solving them in this direct way.

In general, a small amount of lower mathematics, that every technical man is familiar with, may, in many cases, when applied in the right way and the right place, serve to a better understanding of apparently obscure complications.

The largest pin factory in the world is said to be that at Birmingham, England, which has a daily output of 37,000,000 pins.—*Iron Age.*

THE ART OF CUTTING METALS.

The presidential address of Mr. Fred. W. Taylor, before the American Society of Mechanical Engineers, is probably the most valuable paper ever presented before that society. It is a record of experiments extending over a period of 26 years, and its value lies not alone in the data presented concerning the cutting of metals, but also in the fact that, as stated by Mr. Calvin W. Rice in the discussion, it is a record of many incidents to the introduction of the Taylor system.

The address contains 250 pages of text, in addition to 140 drawings and tables, and we can therefore do little more than attempt to convey an idea of its scope. We would, however, urge those who are interested in shop management and operation to obtain a copy and study it carefully. The following abstract is taken from the first part, which gives a history of the experiments. The second part considers the results of the investigation in detail.

"The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop our system of management, the central idea of which is: (A) To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of work. (B) To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance. There are three questions which must be answered each day in every machine shop by every machinist who is running a metal cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

"*a*. What tool shall I use?

"*b*. What cutting speed shall I use?

"*c*. What feed shall I use?

"Our investigations, which were started 26 years ago with the definite purpose of finding the true answers to these questions under all the varying conditions of machine shop practice, have been carried on up to the present time with this as the main object still in view.

Roughing Work Considered Exclusively.

"The writer will confine himself almost exclusively to an attempted solution of this problem as it affects 'roughing work'; *i. e.*, the preparation of the forging or casting for the final finishing cut, which is taken only in those cases where great accuracy or high finish is called for. Fine finishing cuts will not be dealt with. Our principal object will be to describe the fundamental laws and principles which will enable us to do 'roughing work' in the shortest time, whether the cuts are light or heavy, whether the work is rigid or elastic, and whether the machine tools are light and of small driving power, or heavy and rigid with ample driving power. In other words, our problem is to take the work and machines as we find them in a machine shop, and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes, and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these slide rules to tell each workman how to do each piece of work in the quickest time.

"It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for 10 years by a first-class machinist having exceptional knowledge of and experience with his machine and who has been using his best judgment. Yet our observation shows that, on the average, this understates the fact. To make the reason for this more clear, it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of the 12 elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, expert or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these 12 variables and measure their joint effect upon the problem. These 12 elements or variables are as follows:

a. The quality of the metal which is to be cut.
b. The diameter of the work.

c. The depth of the cut.
d. The thickness of the shaving.
e. The elasticity of the work and of the tool.
f. The shape or contour of the cutting edge of the tool, together with its clearance and lip angles.
g. The chemical composition of the steel from which the tool is made, and the heat treatment of the tool.
h. Whether a copious stream of water, or other cooling medium, is used on the tool.
j. The duration of the cut, *i. e.*, the time which a tool must last under pressure of the shaving without being reground.
k. The pressure of the chip or shaving upon the tool.
l. The changes of speed and feed possible in the lathe.
m. The pulling and feeding power of the lathe.

"Broadly speaking, the problem of studying the effect of each of the above variables upon the cutting speed and of making this study practically useful may be divided into four sections, as follows:

"(A) The determination by a series of experiments of the important facts or laws connected with the art of cutting metals.

"(B) The finding of mathematical expressions for these laws which are so simple as to be suited to daily use.

"(C) The investigation of the limitations and possibilities of metal cutting machines.

"(D) The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other the possibilities and limitations of the particular lathe or planer, etc., to which it applies, and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best."

How the Investigation Was Carried On.

The experiments were started in 1880 and continued until 1899 in the works of the Midvale Steel Company, with the aid and encouragement of Mr. William Sellers, at that time its president. At various times since then they have been carried on in the works and at the expense of the Cramps' Shipbuilding Company, William Sellers & Co., the Link-Belt Engineering Company, Dodge & Day and the Bethlehem Steel Company. Most of the results of the experiments have been kept secret up to the present time, and have been given to the different companies in consideration of still further carrying on the work.

Those who were closely associated with Mr. Taylor in carrying on the investigations are Mr. G. M. Sinclair, Mr. H. L. Gantt, Mr. Maunsel White and Mr. Carl G. Barth.

"In carrying on this work more than 10 machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between 30,000 and 50,000 recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 lbs. of steel and iron. More than 16,000 experiments were recorded in the Bethlehem Steel Company. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

"It seems to us that the time has now come for the engineering fraternity to have the results of our work, in spite of the fact that this will cut off our former means of financing the experiments. However, we are in hopes that the money required to complete this work may be obtained from some other source."

Summary of Results.

Following is a chronology of some of the more important discoveries made:

"In 1881, the discovery that a round-nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond-pointed tool.

"In 1881, the demonstration that, broadly speaking, the use of coarse feeds, accompanied by their necessarily slow cutting speeds, would do more work than fine feeds with their accompanying high speeds.

"In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40 per cent. In 1884 a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part; each machine being set in a wrought iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well, from which it was pumped to an overhead tank, from which a system of supply pipes led to each machine. Up to that time the use of water for cooling tools was confined to small cans or tanks, from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884, no other shop in this country was similarly fitted up until the Bethlehem Steel Company in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Company.

"In 1883, the completion of a set of experiments with round-nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

"In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

"In 1883, the development of formulæ which gave mathematical expression to the two broad laws above referred to. Fortunately, these formulæ were of the type capable of logarithmic expression, and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in making our slide rules and solved the whole problem in 1901.

"In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts of varying depths and thickness of shaving.

"In 1883, the starting of a set of experiments on belting described in a paper published in *Transactions*, Vol. 15 (1904).

"In 1883, the measurement of the power required to feed a round-nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that a very dull tool required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel-cutting machines purchased since that time by the Midvale Steel Company have been supplied with feeding power equal to their driving power, and very greatly in excess of that used on standard machine tools.

"In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a toolroom for storing and issuing tools ready ground to the men.

"From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Company, by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

"In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad-nosed tools, which enabled us to run with a coarse feed at as high a speed as had been before attained with round-nosed tools when using a fine feed, thus substituting, for a considerable portion of the work, *coarse feeds and high speeds* for our old maxim of coarse feeds and slow speeds.

"In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals, the gain made by the use of self-hardening tools over tempered tools in cutting soft cast-iron being almost 90 per cent., whereas the gain in cutting hard steels or hard cast-iron was only about 45 per cent. Up to this time the use of Mushet and other self-hardening tools

had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all 'roughing work' throughout the machine shop.

"In 1894 and 1895 the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a gain in cutting speed of self-hardening tools of about 33 per cent. Up to this time the makers of self-hardening steel had warned users not to use water on the tools.

"From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools, namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

"In 1899-1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid everyday use in the shop of all the laws and formulæ deduced from our experiments.

"In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from cast-iron by the tool would permit an increase in cutting speed, and therefore in the amount of work done, of 16 per cent.

"In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high-speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

The Slide Rule and Its Application.

"While many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rules; *i. e.*, the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

"The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object, for which in 1880 the experiments were started, *i. e.*, that of taking the control of the machine shop out of the hands of the many workmen and placing it completely in the hands of the management, thus superseding 'rule of thumb' by scientific control.

"It must be said, therefore, that to get any great benefit from the laws derived from these experiments our slide rules must be used, and these slide rules will be of but little, if any, value under the old style of management, in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed and feed he will use. The slide rules cannot be left at the lathe to be banged about by the machinist. They must be used by a man with reasonably clean hands, and at a table or desk, and this man must write his instructions as to speed, feed, depth of cut, etc., and send them to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have been not only adopted, but enforced, throughout the shop for every detail, large and small, of the shop equipment, as well as for all shop methods.

"Unfortunately, those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples: Under our system the workman is told minutely just what he is to do and how he is to do it; and any improvement which he makes upon the orders given him is fatal to success. While, with the old style, the workman is expected constantly to improve upon his orders and former methods, under our system any improvement, large or small, once decided upon goes into immediate use, and is never allowed to lapse or become obsolete, while under the old system the innovation, unless it meets with the approval of the mechanic (which it never does at the start) is generally for a long time, at least, a positive impediment to success. Thus many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on the old system.

"For this reason the really great gain which will ultimately come from the use of these slide rules will be slow in arriving —mainly, as explained, because of the revolutionary changes needed for their successful use—but it is sure to come in the end.

"A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation that there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods. And this applies not only to large shops, but also to comparatively small establishments. In a company whose employees all told, including officers and salesmen, number about 150 men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20 per cent. upon the old volume of business into an annual profit of more than 20 per cent. upon the new volume of business, and at the same time rendering a lot of disorganized and dissatisfied workmen contented and hard working, by insuring them an average increase of about 35 per cent. in their wages. And I take this opportunity of again saying that these companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management who have had sufficient training and experience to insure success.

Standardization Means Simplification.

"Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have 20 makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management.

"There is, however, one element in which the new type of management to all outward appearance is far more complicated than the old—namely, no standards and no real system of management can be maintained without the supervision, and, what is more, the hard work of men who would be called by the old style of management supernumeraries or non-producers. The man who judges of the complication of his organization only by looking over the names of those on the payroll and separating the so-called non-producers from the producers, finds the new style of management more complicated than the old.

"No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old-fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require, as supernumeraries or non-producers on the payroll, a fireman, an engineer, an oiler and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of non-producers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

Individual Motor Drive.

"There is one recommendation, however, in modern machine shop practice in making which the writer will probably be accused of being old-fashioned or ultra-conservative. Of late

years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works, that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, coupled with the maintenance and repairs, of this system will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs (in most shops entirely too light belts and countershafts of inferior design are used, and the belts are not systematically cared for by one trained man, and this involves a heavy cost for maintenance). There is no question, therefore, that in many cases the motor drive means in the end additional complication and expense rather than simplicity and economy.

"It is at last admitted that there is little, if any, economy in power obtainable through promiscuous motor driving; and it will certainly be found to be a safe rule not to adapt an individual motor for driving any machine tool unless a clearly evident and large saving can be made by it.

Conclusion.

"In concluding let me say that we are now but on the threshold of the coming era of true co-operation. The time is fast going by for the great personal or individual achievement of any one man standing alone and without the help of those around him. And the time is coming when all great things will be done by the co-operation of many men, in which each man performs that function for which he is best suited, each man preserves his own individuality and is supreme in his particular function, and each man at the same time loses none of his originality and proper personal initiative, and yet is controlled by and must work harmoniously with many other men.

"And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are:

"Several men when heartily co-operating, even if of every-day caliber, can accomplish what would be next to impossible for any one man even of exceptional ability.

"Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians, providing only that they are willing to pay the price in time, patience and hard work.

"The old adage is again made good, that all things come to him who waits, if only he works hard enough in the meantime."

Cars and Locomotives Ordered in 1906.—According to the *Railway Age*, there were 310,805 freight cars, 3,402 passenger cars and 5,642 locomotives ordered by the railroads of the United States, Canada and Mexico in 1906, as compared with 341,315, 3,289 and 6,265, respectively, in 1905. Deducting Canadian and Mexican orders from shops in the two countries and 28,810 cars ordered by railroads of the United States from their own shops, the number of freight cars ordered from contract shops in the United States in 1906 is found to be 258,866, as against 302,876 in 1905. A total of 142,172, or 46 per cent., of the freight cars ordered in 1906 were specified to be of steel or to have steel underframes. It is estimated that, while the contract shops had a capacity of 175,000 cars in 1905, the present capacity is 200,000 cars, and that of 1907 will be 250,000 cars. It is also estimated that two-thirds of the capacity for 1907 is engaged by the orders now in hand.

New Home of the A. S. M. E.—On January 1 the American Society of Mechanical Engineers removed its headquarters to the new Engineering Societies Building at 29 West Thirty-ninth street, New York City.

PACIFIC TYPE LOCOMOTIVES.

NATIONAL RAILWAY OF MEXICO.

The National Railway of Mexico has recently purchased six Pacific type passenger locomotives, which include an example of four different cylinder arrangements and of both Walschaert and Stephenson valve gear. Five of these were built by the American Locomotive Company, and consist of three simple engines, one Cole balanced compound, and one simple engine fitted with Alfree-Hubbell valves and cylinders. The sixth engine is a Baldwin four-cylinder balanced compound, built by the Baldwin Locomotive Works.

All of these locomotives are of practically the same design outside of the cylinder arrangement, and all have Stephenson valve gear except the Cole compound. The Baldwin engine differs from the others in several details, some of which will be referred to later. The simple engines carry 200 lbs. steam pressure and the compounds 220 lbs.

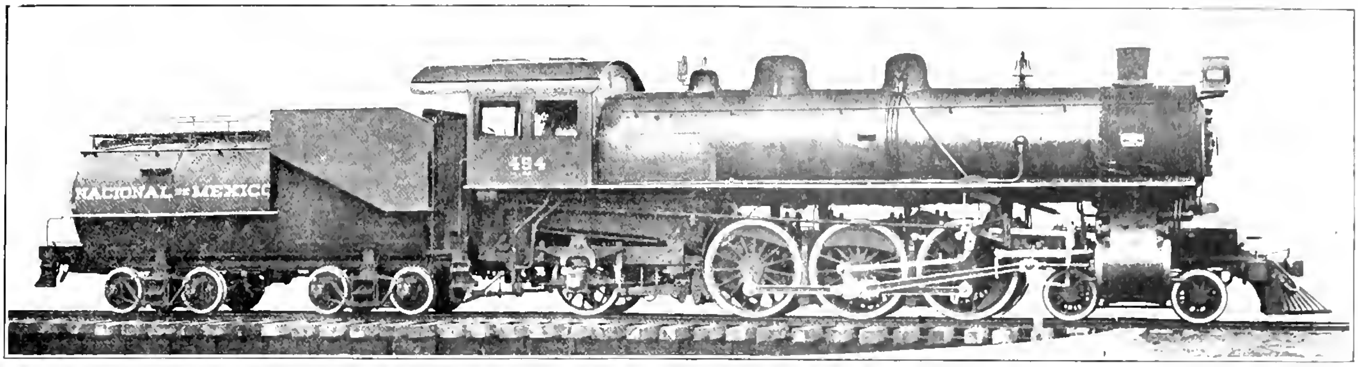
The three simple engines with Richardson slide valves weigh 222,500 lbs. total, of which 141,300 lbs. is on drivers, giving an average weight of 47,100 lbs. per axle on a rigid wheel base of 12 ft. 3 ins. This weight, for a wheel base of 12 ft., is exceeded by but one other simple high speed locomotive on our records, viz.: the Northern Pacific 4-6-2 type, which weighs 49,170 lbs. per axle. It, however, is often exceeded in other types of three coupled simple locomotives for moderately high speed work, as well as in balanced compounds of the 4-6-2 type. The wheels are 67 ins. diameter, and the cylinders have a diameter of 22 ins. and a 28-in. stroke, which gives a tractive effort of 34,400 lbs. at 85 per cent. boiler pressure. The factor of adhesion is 4.11.

The boilers are of the straight type, 74½ ins. in diameter at the front ring. They contain 306 2¼-in. tubes 20 ft. long, giving a tube heating surface of 3,588 sq. ft. The firebox heating surface of 210.3 sq. ft. is 5.55 per cent. of the total. The grate area of 51.6 sq. ft. gives 1 sq. ft. to every 73.2 sq. ft. of total actual heating surface and to 17.5 sq. ft. of equated heating surface. These ratios indicate that with a moderately good grade of coal there should be no difficulty in furnishing all the steam needed. The fireboxes are radially stayed and an unusually deep throat is provided.

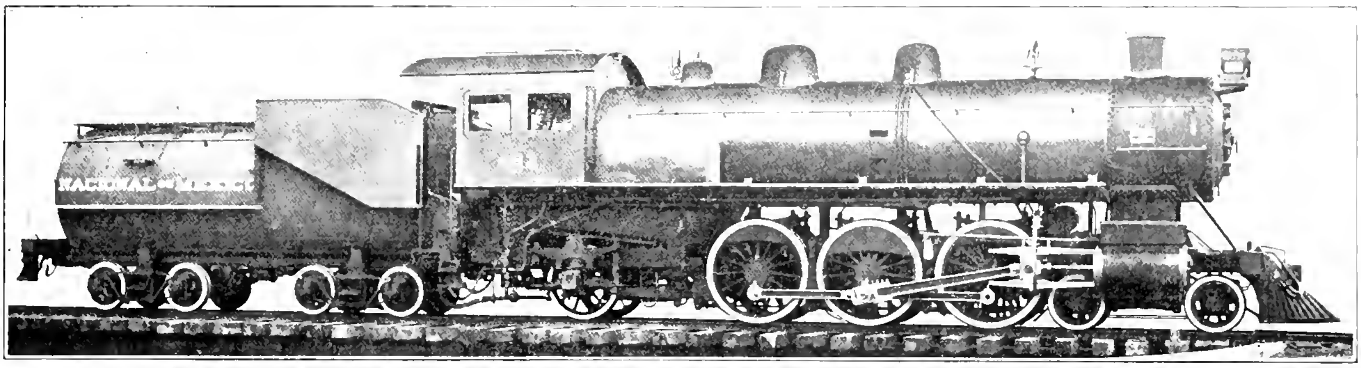
The accompanying table of dimensions will permit a comparison of the ratios and dimensions of these locomotives with one of approximately the same size and power recently built for the Chicago, Burlington & Quincy Railway.

The locomotive fitted with the Alfree-Hubbell valves and cylinders is not different in other respects from the one above considered. This arrangement of cylinders, as applied to a consolidation locomotive on the Chicago, Rock Island & Pacific Railway, has been thoroughly described and illustrated.* The principal features of this design are that it gives a delayed exhaust opening and closure for all points of cut-off, an increased exhaust area and a large reduction in cylinder clearance. In the present case with a cut-off at 6¾ ins., the exhaust opens at 21⅞ ins. and closes at 25¼ ins., giving but 2¾ ins. compression. This delayed exhaust closure permits the large reduction in cylinder clearance which has been accomplished. The reduction in this case is from 8 per cent. to 2½ per cent. of the stroke in the cylinder and over 70 per cent. of the port volume. In brief, the construction consists of a very long steam valve set at an angle of 15 degs., with the transverse horizontal and as close to the cylinder as possible, the top wall of the cylinder forming the valve seat. The cylinder ports are practically straight and give an opening on the valve seat equal to the diameter of the cylinder. The increased area for the exhaust and the delayed exhaust closure is obtained by means of a supplementary compression controlling valve which is operated from a dash pot connection on the main valve. It consists of piston valves about 5 ins. diameter equipped with wide special rings which fit openings

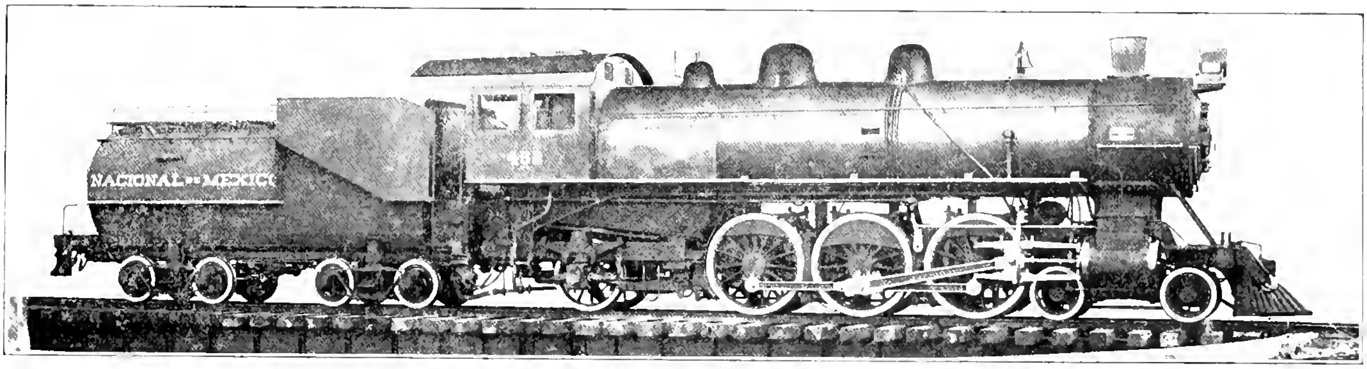
*See American Engineer, September, 1906, pp. 334.



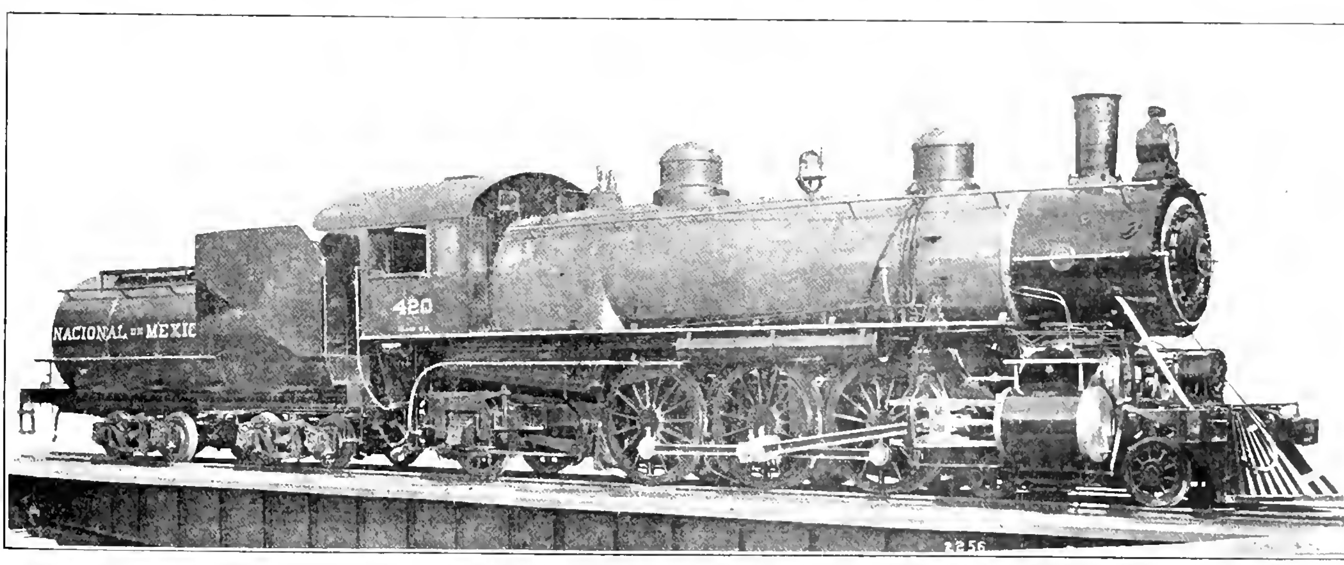
COLE BALANCED COMPOUND LOCOMOTIVE.



ALLFREE-HUBBELL TYPE LOCOMOTIVE.

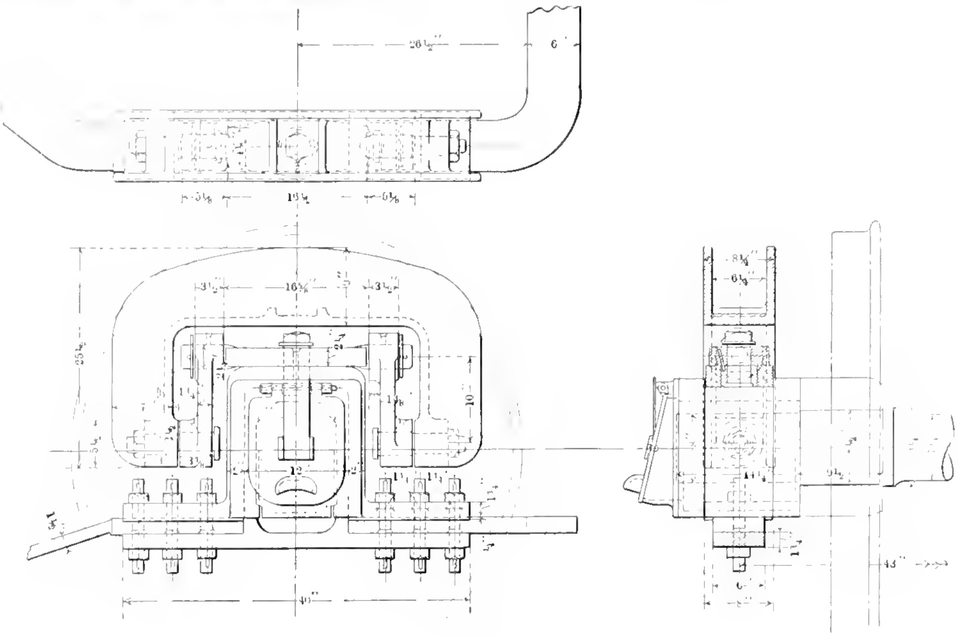


SIMPLE SLIDE VALVE LOCOMOTIVE.

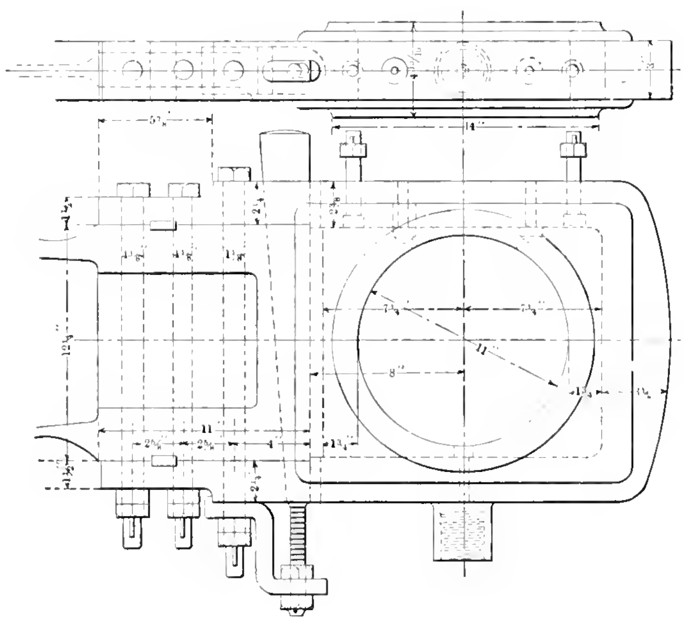


BALDWIN BALANCED COMPOUND LOCOMOTIVE.

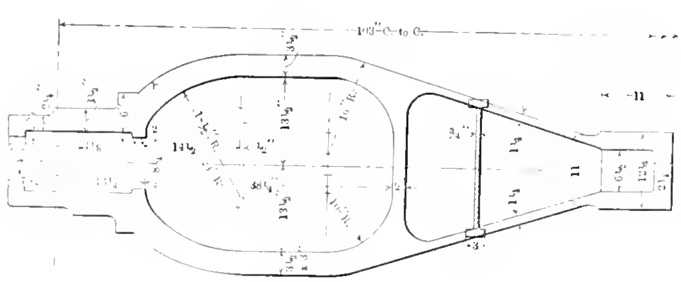
PACIFIC TYPE LOCOMOTIVES—MEXICAN NATIONAL RAILWAY.



BUSHTON TRAILER TRUCK.



CRANK END OF BIFURCATED MAIN ROD.

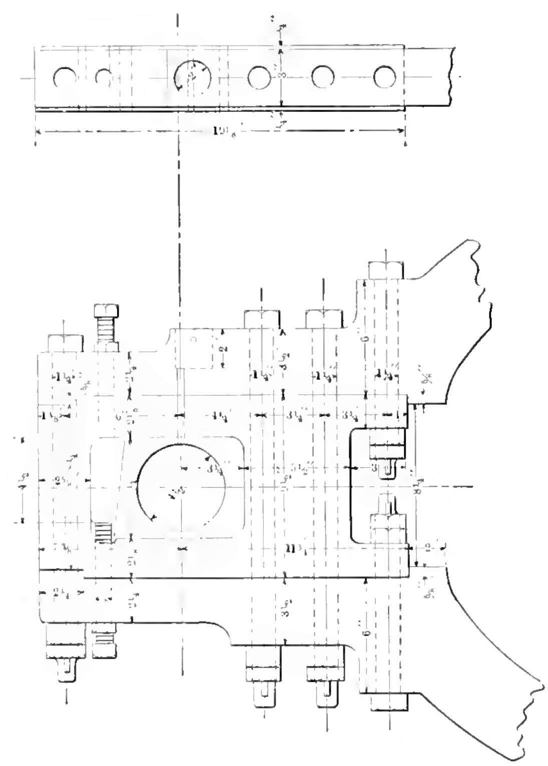


BIFURCATED MAIN ROD.

in the wall between the steam port and exhaust passage. These are so connected to the main valve that they open simultaneously with the opening of the exhaust edge of that valve, but do not close until it has moved 1¼ ins. beyond the point of exhaust closure. The area of these openings is 19 sq. ins., and is sufficient to hold down the back pressure line to very near the end of the stroke. The delayed exhaust opening is obtained by using a 7-16 in. exhaust lap on the main valve. The main steam valves are so designed that even in the shortest valve travel one portion of the valve laps the travel of another part on the valve seat, and thus produces a uniform wearing effect.

This design of valves and cylinders has now been in operation in both heavy freight and high speed passenger service for over a year on other roads with the most satisfactory results, both as regards economy of operation and maintenance, as well as in giving a very quick and responsive engine.

The Cole balanced compound in this order is the second application of this design to a Pacific type locomotive, the former being the one built for the Northern Pacific Railway. This engine was very completely illustrated and described in this journal in November, 1906, page 411, and since the Mexican National locomotive is practically a duplication of that design, as far as cylinders are concerned, reference



CROSSHEAD END OF BIFURCATED MAIN ROD.

can be made to that article for all details. This locomotive differs from the simple engines just mentioned, in the fact that the cylinders have been moved 12 ins. ahead and the forward pair of driving wheels 3 ins. back, thereby increasing the distance between the forward driving wheels and the center of the saddle by 15 ins. and lengthening the boiler by 12 ins., this increase being ahead of the front flue sheet. A noticeable difference is found in this design as compared with previous Cole compounds, in the fact that the high pressure cylinders have a stroke of but 26 ins., while the low pressure cylinders have a 28-in. stroke. This has been done for the purpose of making the angularity of the high and low pressure rods more nearly equal, and has also resulted in reducing the weight of the cranked axle. Reference to the accompanying table of dimensions will give a comparison between these two locomotives, as well as other balanced compounds, and in considering this table it should be remembered that the boiler of the Northern

Owner	Mex. Nat.	Mex. Nat.	C., B. & Q.	Mex. Nat.	A., T. & S. F.	Mex. Net.	N. P.
Kind of cylinders	Simple	Allfree-Hubble	Simple	Bald. Comp.	Bald. Comp.	Cole Comp.	Cole Comp.
Builder	American	American	Baldwin	Baldwin	Baldwin	American	American
Tractive effort, lbs.	34,400	34,400	32,690	35,066	32,250	31,900	30,340
Weight in working order, lbs.	222,500	223,500	230,940	227,340	226,700	241,000	240,000
Weight on drivers, lbs.	141,300	142,000	151,290	147,040	151,900	150,000	157,000
Weight of engine and tender in working order, lbs.	358,300	359,300	382,000	370,000	402,783	377,200	380,500
Wheel base, driving, ft. and ins.	12-3	12-3	12-10	12-0	13-8	12-0	12-0
Wheel base, total, ft. and ins.	33-0	33-0	32-9	33-11	34-0	34-0	33-5
Wheel base, engine and tender, ft. and ins.	63-3¼	63-3¼	64-3¼	62-11	66-1½	64-3¼	62-10
RATIOS.							
Weight on drivers ÷ tractive effort	4.11	4.13	4.63	4.2	4.75	4.7	5.18
Total weight ÷ tractive effort	6.47	6.5	7.07	6.46	7.	7.55	7.9
Tractive effort x diam. drivers ÷ heating surface	610.	610.	615.	632.	655.	562.	720.
Total heating surface ÷ grate area	73.2	73.2	72.8	71.2	68.	73.5	67.
Firebox heating surface ÷ total heating surface (per cent.)	5.55	5.55	4.85	5.	5.38	5.55	8.3
Weight on drivers ÷ total heating surface	37.2	37.5	38.5	37.4	42.3	39.5	53.8
Total weight ÷ total heat. surface.	58.7	58.9	59	61.1	63.1	63.5	82.5
Volume both cylinders, cu. ft.	12.32	12.32	12.32	11.5	11.5	10.27	9.9
Total heating surface ÷ vol. cylinders	308	308.	318.	322.	312.	370.	294.
Grate area ÷ vol. cylinders	4.18	4.18	4.46	4.54	4.61	5.	4 3
CYLINDERS.							
Number	2	2	2	4	4	4	4
Diameter, ins.	22	22	22	17 & 28	17 & 28	16½ & 27	16½ & 27½
Stroke, ins.	28	28	28	28	28	26 & 28	26
VALVES.							
Kind	Bal. Slide	Bal. Slide	Piston	Piston	Piston	Piston	Piston
Diameter, in.	......	......	12	15	......	......	14
WHEELS.							
Driving, diameter over tires, in.	67	67	74	67	73	67	69
Driving, thickness of tires, in.	3½	3½	4	3½	3½	3½	3½
Driving journals, main, diam. and length, in.	10x12	10x12	9½x12	11x10	11x10	10x12	11x11½
Driving journals, others, diam. and length, in.	9x12	9x12	......	9x12	9x12	F 11x11¼-B 10x12	9½x12
Engine truck wheels, diam., in.	33	33	37¼	30	31¼	33	33½
Engine truck, journals, in.	6x12	6x12	6x12	6x10	6x10	6x12	6½x12
Trailing truck wheels, diam., in.	50	50	48	48	43	50	45
Trailing truck, journals, in.	8x14	8x14	8x12	8x14	7½x12	8x14	8x14
BOILER.							
Style	Str.	Str.	W. T.	W. T.	W. T.	Str.	E. W. T.
Working pressure, lbs.	200	200	210	220	220	220	220
Outside diameter of first ring, in.	74½	74½	70	70	70	74⅝	72¼
Firebox, length and width, in.	113⅛x65¼	113⅛x65¼	108⅛x72¼	113½x66¼	108x71¼	113⅛x65¼	96x65¼
Firebox plates, thickness, in.	⅜ & ½	⅜ & ½	⅜ & ½	⅜ & ½	⅜ & ½	⅜ & ½	⅜
Firebox, water space, in.	F 4½-S & B 4	F 4½-S & B 4	F 4½-S & B 4	F 4½-S & B 4	F 4½-S 5-B 4	F 4½-S & B 4	F 4½-S & B 4
Tubes, number and outside diam., in.	306-2¼	306-2¼	303-2¼	301-2¼	290-2¼	306-2¼	306-2
Tubes, length, ft. and ins.	20-0	20-0	21-0	20-0	20-0	20-0	16-9
Heating surface, tubes, sq. ft.	3588.	3588.	3732.	3527.	3402.2	3588.	2667.
Heating surface, firebox, sq. ft.	210.3	210.3	190.	186.	192.8	210.3	241.8
Heating surface, total, sq. ft.	3798.3	3798.3	3933	3713.	3595	3,798.3	2908.8
Grate area, sq. ft.	51.6	51.6	54	52.1	53.	51.6	43.5
Smokestack, diameter, in.	18	18	......	......	......	18	18
Smokestack, height above rail, in.	180	180	......	......	......	180	185½
Centre of boiler above rail, in.	......	......	110	109	......	116	115
TENDER.							
Tank	Vanderbilt	Vanderbilt	Water Bot.	Vanderbilt	Water Bot.	Vanderbilt	Water Bot.
Frame	6"x4" Angles	6"x4" Angles	Steel	Steel	Steel	6x4 Angles	13" Chan.
Weight	135,800	135,800	151,060	142,660	176,083	136,200	140,500
Wheels, diameter, in.	33	33	37¼	33	34½	33	33½
Journals, diameter and length, in.	5½x10	5½x10	5½x10	5½x10	5½x10	5½x10	5½x10
Water capacity, gals.	7,500	7,500	8,000	7,500	8,500	7,500	7,000
Coal capacity, tons	12	12	16	12	3,300 G	12	12
Reference in the AMERICAN ENGINEER			8-06, p 302		12-05, p 454		11-06, p 411

Pacific locomotive has a combustion chamber, which largely reduces its actual total heating surface.

The Baldwin balanced compound locomotive differs from the others outside of the cylinder and its connection principally in the fact that it has an extended wagon top boiler and that Stephenson valve gear with eccentrics on the third axle and a very long valve rod is provided. The boiler, although of smaller diameter in front, is of practically the same capacity, having but five less flues and a slightly smaller firebox heating surface. The valve rod, which extends along the top of the frame, is supported at two intermediate points and is provided with a knuckle joint about 5 ft. ahead of the rocker arm, the total distance from the rocker arm to the valve chamber being about 15 ft. The frame centers are 44 ins. apart except for a short distance at the main driving wheels, where it has been increased to 45½ ins. in order to secure a main driving journal 10 ins. long between the cheek of the cranked axle and the face of the wheel hub.

This locomotive is very similar to one built in 1905 for the Atchison, Topeka & Santa Fe Railway. The cranked axle is on the second pair of drivers, and the main rod from the high pressure cylinders is of a bifurcated design spanning the front axle. A difference is noticed in this later design of main rod, as will be seen in the illustration, in the fact that the front end of the rod is provided with lips which bear against the body of the stub, thus relieving the stub bolts of the large shearing stress which necessarily accompanies the starting and stopping of a heavy rod of this design. The front brass is split and is provided with a wedge adjustment. The back stub is fitted with the usual strap and key. Reference can be made to the description of the Santa Fe locomotive mentioned for an illustration of the previous design of this rod. The crank axle is built up of 7 pieces of a design recently illustrated in connection with the balanced compound Prairie type for the Santa Fe.

The trailing truck of this locomotive is of the Rushton type, it, however, in this case being arranged for outside journals. As can be seen in the illustration, the box is held rigidly between the pedestals and the cast steel equalizer or spring seat is suspended directly on the swing links. The bearings for the swing links are bolted to a supplementary frame, which is secured to the main frame by means of cast steel brackets.

The tenders of all of these locomotives are of the Vanderbilt type with a capacity of 7,500 gals. of water and 12 tons of coal.

This order of locomotives, which includes four different cylinder arrangements on locomotives practically identical in other respects, gives the National Railways of Mexico an exceptional opportunity to try out these features, and develop

their possibilities in actual service under the conditions found on its railways.

Baldwin Balanced Compound Locomotives have been illustrated and described in this journal as follows: Plant System, 4-6-0, March, 1902, page 72. A. T. & S. F. Ry., 4-4-2, June, 1903, page 212. C. B. & Q., 4-4-2, June, 1904, page 211. N. Y., N. H. & H., 4-6-0, December, 1904, page 466. C. & E. I. Ry., 4-6-0, March, 1905, page 97. N. Y. C. & H. R. R. R., 4-4-2, April, 1905, page 109. Erie R. R., 4-4-2, May, 1905, page 177. O. R. & N., 4-6-2, July, 1905, page 246. C. R. I. & P., 4-4-2, November, 1905, page 416. A. T. & S. F., 4-6-2, December, 1905, page 455. A. T. & S. F. 2-6-2, November and December, 1906, pages 434 and 481. U. P. R. R., 4-4-2, August, 1906, page 308. N. C. & St. L. Ry., 4-6-0, February, 1906, page 69. P. R. R., 4-4-2, February, 1906, page 70.

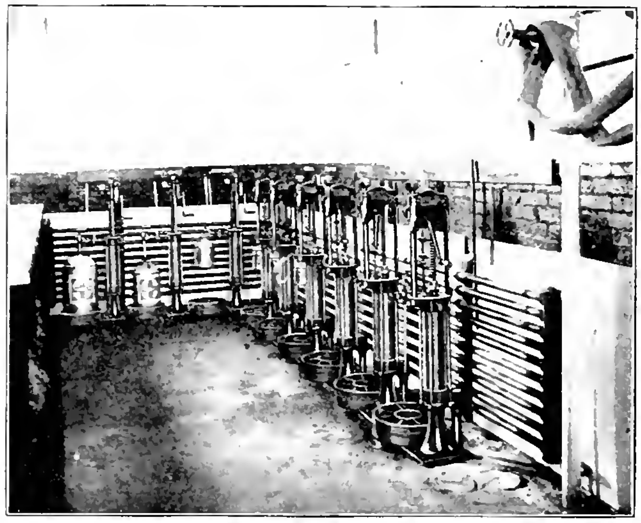
Cole Balanced Compound Locomotives have been illustrated and described in this journal as follows: N. Y. C. & H. R. R. R., 4-4-2, May and June, 1904, pages 166 and 240. Erie R. R., 4-4-2, August, 1905, page 287. P. R. R., 4-4-2, February, 1906, page 70. N. P. Ry., 4-6-2, November, 1906, page 411.

INEFFICIENT TRANSPORTATION FACILITIES.—To many witnesses at both Minneapolis and Chicago it was obvious that if cars were made to move faster and were kept moving, their efficiency would be greatly increased. Car shortage, in other words, may result as much from lack of wise methods in handling the cars which a company possesses as from a deficiency in the number of cars or a lack of tractive power. If engines are made to haul their maximum, it is manifest that their capacity is limited to the highest grade over which they are compelled to pass. If trains are made up of so large a number of loaded cars that the engine is reduced to its minimum speed, these cars during their time of transit are withdrawn from the general car supply. From the statistics presented it would appear that the policy of hauling maximum loads on long hauls is one that produces dazzling figures of ton mileage which should greatly gratify the railroad stockholder did not the troublesome problem arise of the carrier's duty to render prompt service and make the fullest possible use of the railway and its facilities. Maximum tonnage and maximum service are not necessarily equivalents. A railroad which lives by virtue of a public grant and the exercise of quasi-public powers is primarily obligated to discharge its functions with an eye to the welfare of the public which it serves and to avoid any policy of operation which, no matter how profitable to the stockholder, may result injuriously to its dependent communities.—*Interstate Commerce Commission Investigation.*

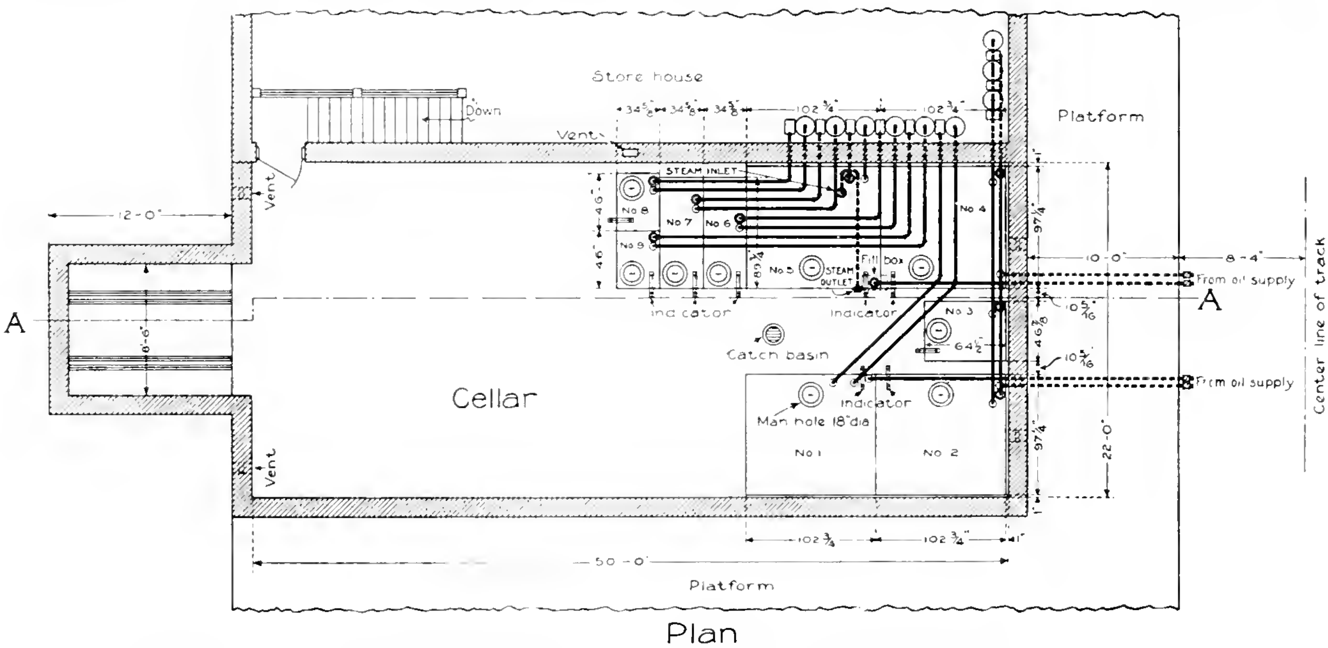
Opportunity for talent at this time is unlimited. From an organization and economical standpoint, generally speaking, the actual operation of railroads is in its infancy. We have, indeed, hardly begun.—*Mr. D. T. Taylor, St. Louis Ry. Club.*

OIL STORAGE ON THE SANTA FE.

Railroads everywhere are confronted with the serious problem of how to store and handle the various oils which are used. To keep the oil in barrels and drums entails considerable loss from leakage, waste, evaporation and seepage. Gravity systems have been tried and found unsatisfactory—very little better than the barrel storage method. Faucet tanks are at best unsightly, and the losses they allow total a considerable sum in a very short time. Then, too, aside from the actual oil loss, these methods are unsafe—they increase the fire risk because of the oil-soaked floors, leaking, overflowing oil and vapor-laden atmosphere, for which they are responsible.



CORNER OF STOREHOUSE SHOWING THE SELF-MEASURING PUMPS WHICH ARE CONNECTED WITH TANKS IN THE BASEMENT.



FIRST FLOOR PLAN OF OIL STORAGE SECTION OF SANTA FE STOREHOUSE AT SHOPTON (FORT MADISON), IOWA.

The equipment recently installed in the storehouse of the Atchison, Topeka & Santa Fe Railway at Fort Madison, Iowa, by S. F. Bowser & Co., Inc., Fort Wayne, Ind., has solved for this railroad the various problems with which they have been confronted, and as similar equipments have been installed at other points along the Santa Fe System and also in the storehouses of a score of other railroads, a brief description of the Fort Madison installation may be of interest.

All of the oils are stored in tanks of the desired capacity located in the basement of the storehouse. The oils so handled and the capacities of the tanks are as follows:

No. 1. 3,000 gals. engine oil.
No. 2. 3,000 gals. kerosene oil.
No. 3. 600 gals. special coach.
No. 4. 3,000 gals. car oil.
No. 5. 3,000 gals. valve oil.
No. 6. 600 gals. mineral seal.
No. 7. 600 gals. signal.
No. 8. 300 gals. common black.
No. 9. 300 gals. turpentine.

By referring to the plan drawing, the location of the tanks, designated by the above numbers, may be readily ascertained.

On the storeroom floor at the point most convenient for disbursing the oils are located nine long-distance, self-measuring pumps. These pumps are so designed that any kind of oil can be drawn from the tank to any part of the building. They are self-measuring; that is, a full stroke delivers an accurate gallon, while at the option of the operator they may be quickly adjusted to deliver a pint, a quart or a half-gallon at a stroke, as desired. The oil is, therefore, drawn and measured, at one operation, directly into the can to be filled without using funnels or measures.

The pumps are furnished with gallon meters, which keep an accurate record of all oil pumped; with discharge registers, which record the number of gallons pumped at each operation, and so prevent pumping more oil than was intended; with anti-drip nozzles, which shut off the flow of oil the instant pumping ceases; with self-locking devices, so that only authorized employes provided with keys can draw oil. The tanks are all vented to the outside of the building, thus providing an exit for excess gases; with manholes, making the tanks readily accessible for cleaning, etc., and with storage indicators, showing the amount of oil remaining in each tank and serving as a check on the delivery.

To provide for replenishing the tanks, each is equipped with a fill pipe running to the outside of the storehouse, so that they may be filled directly from the supply car on the tracks or from barrels on the outside platform.

This system of oil storage and control insures against all oil losses. It reduces to a minimum the time and labor involved in handling the oils, and removes all risk of fire. With it the oil room may easily be kept clean. As the oils are kept in an air-tight tank, and are not exposed to the air at any time, no dust, dirt or grit can become mixed with the oil and it is always kept clean and pure.

SHOE AND WEDGE CHUCK.

The shoe and wedge chuck, shown in Fig. 1, was designed by Mr. D. T. Rice, formerly with the Wabash Railroad. Not only does it make possible a saving in the time of setting the castings on the machine, but there is also a considerable saving in the time of machining, due to the use of the special tool shown in Fig. 3. The shoes and wedges are held in place

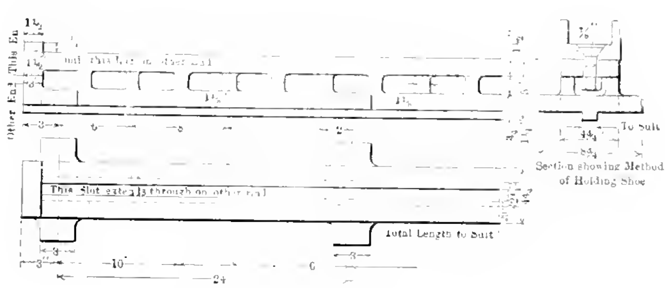


FIG. 1.—SHOE AND WEDGE CHUCK.

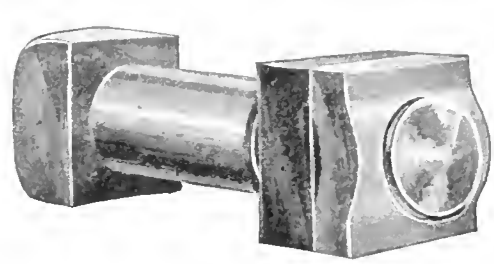
by taper head bolts, as shown. The holes are cored by green sand cores, and no drilling or chipping need be done before the castings are taken to the planer.

Butting the castings end to end, the chuck is filled and the nuts on the taper bolts are tightened by a wrench working between the ribs of the chuck. The tool shown in Fig. 3 is then used for taking a roughing and finishing cut down the inner sides of the flanges. The tools may readily be adjusted for various widths of frame fits. The bottom surface is finished with an ordinary tool, after which both outside surfaces of the flanges are finished at the same time by using two planer heads. The castings are then ready to be fitted by the erecting gang.

The installation of this device was instrumental in saving two-thirds of the time required for setting the shoes and wedges by old methods and in reducing the time of machining approximately one-half. The same chuck could, of course, be used to advantage on a milling machine.

A NEW LOCK NUT.

A lock nut, known as the "Grip Nut," has recently been placed on the market, which combines the following desirable qualities: It may be placed in any position on the bolt; may be tightened any portion of a turn or several turns when necessary, and is durable, simple and inexpensive. It is a one-piece steel nut, made from bars rolled with an arch or



"GRIP NUT."

bow along the center. The nut is punched, cut off and tapped in the usual manner, after which the operation is performed which makes it so effective as a lock nut. This consists in running the nuts through a deflecting press which depresses the threads in the arch at each end, or in other words, the arch threads are straightened as compared to the true spiral of the original thread. These deflected threads grip the bolt in a friction lock which cannot be loosened by vibration.

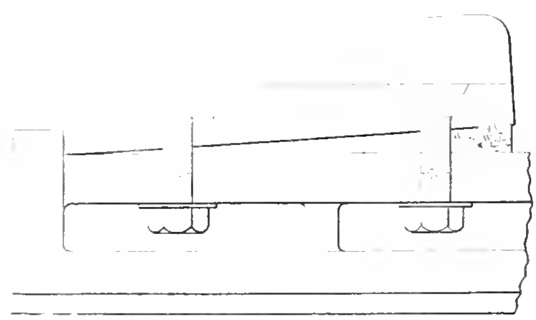


FIG. 2.—METHOD OF HOLDING SHOE.

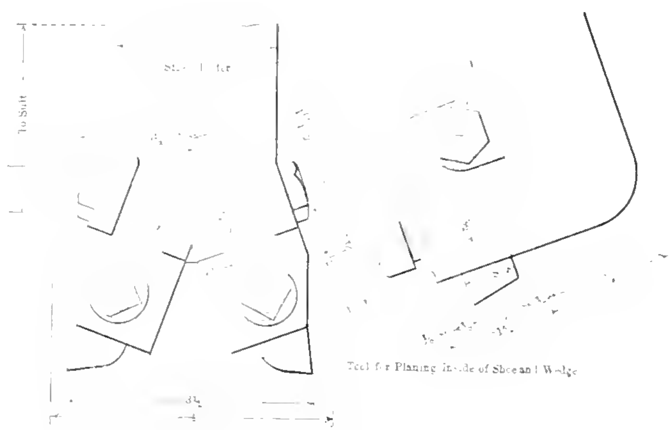


FIG. 3.—PLANER TOOL FOR FINISHING INSIDE OF FLANGES.

The nuts may readily be removed with a wrench and can be used many times.

It is not necessary to jam the "Grip Nut" against the first nut, as it does not depend upon the friction of contact with the first nut for its holding power, but locks itself upon the threads of the bolt because of its slightly deflected threads. It therefore cannot be classed as a jam or a split nut, and does not require spring lock washers, cotter pins, keys and other similar devices. It requires no change in the standard bolt. The nuts have been tested in severe service, in both frog, crossing and car truck work, for three years, and are said to have fully demonstrated their value and effectiveness for work of this kind.

R. W. Hunt & Co. recently tested these nuts for strength and efficiency, and also determined the frictional resistance of the different sizes from $\frac{3}{8}$ in. to 1 in., inclusive. The smaller size "Grip Nuts" were found to be as strong as the bolt, while the 1-in. nuts were 65 per cent. as strong as the bolts, the tensile strength of the bolt material being taken at 65,000 lbs. per square inch. In a test of the frictional resistance on a 1-in. track bolt when screwed on until the bearing face of the nut was $1\frac{1}{4}$ ins. from the end of the bolt, the pull necessary to unscrew the nut with a wrench having a radius of 18 ins. was 34 lbs. and the turning moment 612 in. lbs. The pull necessary to unscrew the nut when force was applied at its corner was 583 lbs., and that necessary at the thread 1,224 lbs.

At present these nuts are being used extensively on electric railway tracks and equipment, especially on high speed interurban roads. These nuts are made by the Grip Nut Company, with offices at 152 Lake street, Chicago, and 500 Fifth avenue, New York. A new mill has recently been completed, which has a capacity for nearly 200,000 of these nuts per day, but it is expected that this will have to be enlarged in the near future.

VARIABLE SPEED PLANER.

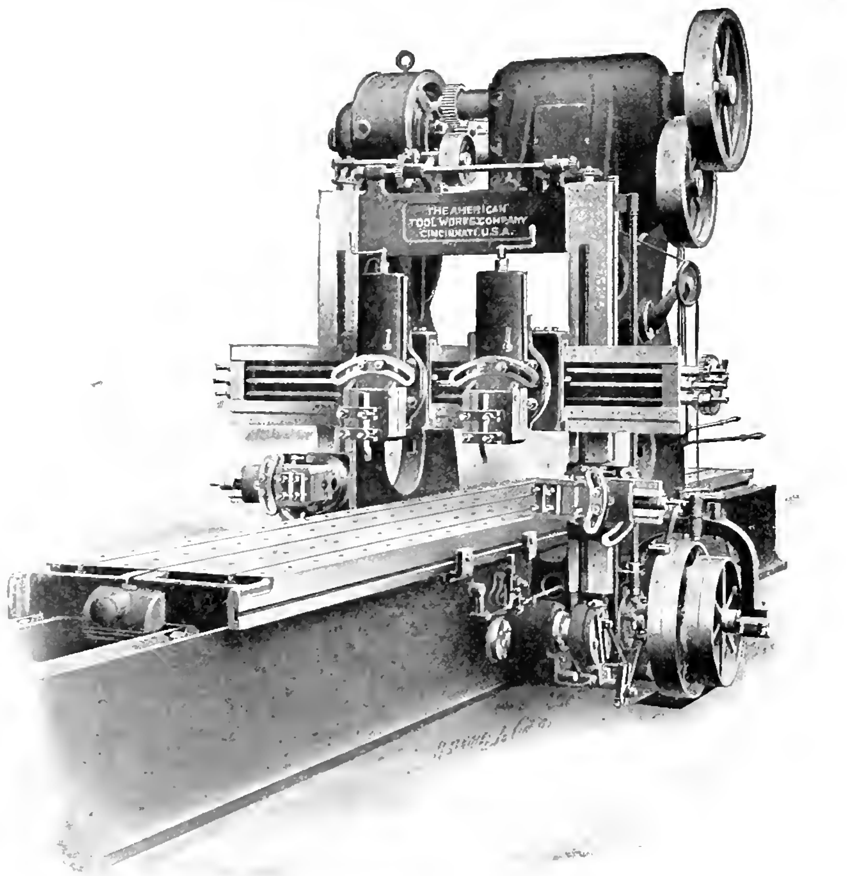
To meet the demand for variable speed planers for certain classes of work, with the resultant increase in output, the American Tool Works Company, of Cincinnati, has developed two lines of variable speed planers, one furnishing four different cutting speeds with a constant return speed, and the other two cutting speeds with a constant return speed.

Any one of the cutting speeds on the planer furnishing four cutting speeds may quickly be obtained by means of two levers, conveniently placed. An index plate shows how to obtain the desired speed. The different speeds are furnished by a speed box, and an interlocking device is provided to prevent engaging two conflicting speeds at the same time. The speed box has been carefully designed with a view to efficiency, durability and simplicity, and the speeds have been carefully selected to meet the requirements of up-to-date planer practice. The platen has a constant high speed return, and this, in conjunction with the variable cutting speeds, makes it possible to attain a high degree of efficiency, especially in cases where it is necessary to do a variety of work on the same planer.

The speed box is bolted to the top of the housings, which are especially designed to furnish it a substantial support. The speed box gears run in oil, the box being entirely enclosed, thus reducing the noise to a minimum, insuring economy of oil consumption and freedom from flying oil. The gears are of ample proportions, with wide faces and coarse pitch. The pinions are of steel, cut intregal with the shafts. Special cutters are used for cutting the gears to insure accuracy, long life and minimum noise. All shafts in the speed box run in long bronze bushed bearings, provided with ring oilers. No friction clutches or drives are used.

The driving pulleys have flywheel rims, reducing shocks to the driving mechanism, due to reversal, to a minimum and furnishing a steady, even pull at the cutting tool. The careful design of the driving mechanism and planer details makes it possible to turn out a high grade and accurate class of work.

The planers are furnished with either a belt or motor drive. If on the motor driven machine the motor should get out of order, the driving pinion on the outside of the speed box may be replaced by a pulley and the planer be driven by the belt from a countershaft or another motor conveniently placed. The flexibility of this construction insures the constant use of the machine at all times. The belt driven planer may readily be equipped with a motor drive at any time after installation.



AMERICAN VARIABLE SPEED PLANER.

The planers equipped for two cutting speeds with a constant return speed are driven from a simple two-speed countershaft, which is self-oiling, thus requiring a minimum amount of attention.

THE PENNSYLVANIA RAILROAD LOCOMOTIVE TESTING PLANT.

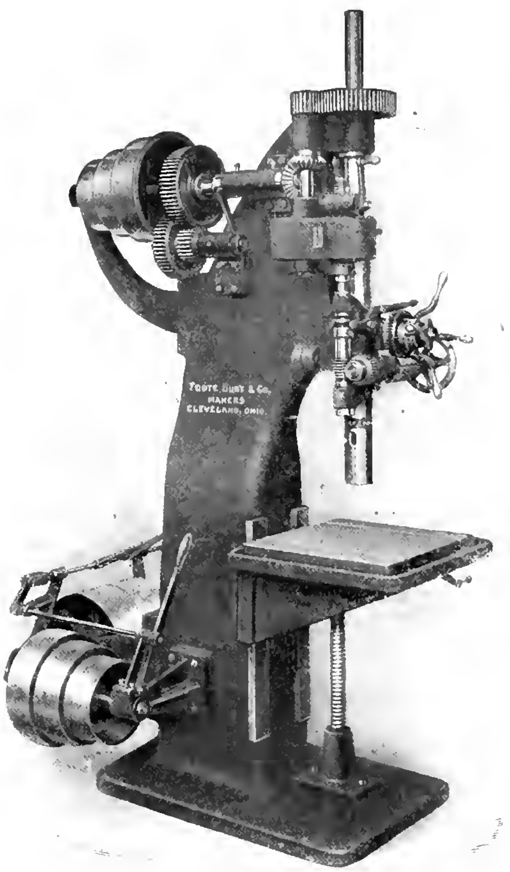
The locomotive testing plant of the Pennsylvania Railroad has been installed and is now in operation in a specially designed building at Altoona, Pa. The original program of tests, which it was impossible to complete at St. Louis, is being continued, and at present a Pennsylvania class E-3-A, which is a 20½ x 26-in. simple Atlantic type locomotive, with slide valves, Stephenson valve gear and Belpaire boiler carrying 205 lbs. pressure, is being tested. It will be remembered that all the passenger locomotives tested at St. Louis were of the four-cylinder balanced compound design, and it is expected that the results from a simple locomotive of the same type will be of much value for comparison. It is proposed to follow this locomotive with one of the class E-3-B, which is

of the same design in all respects, except that it has Walschaert valve gear and piston valves.

These tests are being carried on with the same grade of coal and with all the influencing conditions, as far as possible, the same as at St. Louis.

HIGH DUTY VERTICAL DRILL.

The use of high speed steel drills has made it necessary to radically change the design of vertical drills. The illustration shows a recent design of Foote, Burt & Co., which is guaranteed to drive high speed drills, up to and including 2¼ ins.



FOOTE-BURT HIGH DUTY DRILL.

in diameter, to the limit of their capacity. The design of the column, the method of attaching and supporting the table, and the size and arrangement of the spindle are such that under the above conditions there is no deflection between the point of the drill and the table, thus allowing the drills to be operated economically and eliminating danger of breakage due to the drill "catching."

The drills may be furnished either with or without the back gear and the right angle drive, as shown. They are built in two sizes, 24 and 36-in. swing. The leading dimensions are as follows:

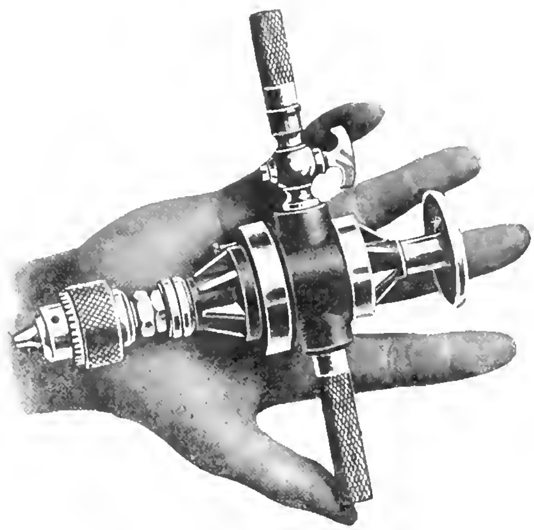
Maximum distance nose of spindle to top of table	32 ins.
Distance from center of spindle to face of column	12 or 18 ins.
Power feed to spindle	16 ins.
Size of spindle in sleeve	2¼ ins.
Three changes of geared feed for each spindle speed,	.007 in., .016 in., .033 in.
Spindle feed rack of steel	1¾-in. face
Size of table inside of oil pockets	20x20 ins., with 2 T slots
Ratio of back gearing	3½ to 1
Weight	2,680 lbs.

The spindle is of forged high carbon steel. The sleeve is 23 ins. long. Ball-bearing thrust collars of the Foote-Burt design are provided, using balls ⅝ in. in diameter. These are guaranteed to work satisfactorily under the most severe service without breakage of balls or crushing out of the collars.

Three changes of geared feed are provided, any one of which is instantly available by shifting a lever conveniently located. The hand worm feed, automatic stop and quick return levers are all within convenient reaching distance of the operator. The table is fitted to the column by a square locked slide and is clamped by straps. It is also supported underneath by a 2-in. square thread screw, which acts as a solid jack and at the same time elevates the table.

THE CHICAGO MIDGET ROTARY DRILL.

A rather unique and novel but useful air drill having a capacity for drilling up to 3-16 in. in steel and known as the "Midget Drill" has been placed upon the market by the Chicago Pneumatic Tool Company. The illustration compares it in size to a man's hand. It weighs complete only 2½ lbs.; the distance from the breast plate to the end of the spindle is 7⅝ ins.; from the center of the spindle to the outside of the housing, 1 in.; the motor speed is 22,000 r.p.m., and the



CHICAGO MIDGET PNEUMATIC DRILL.

spindle speed, 2,000 r.p.m. It is of the rotary type and is adapted for drilling tell-tale holes in staybolts or general light work where accuracy is required.

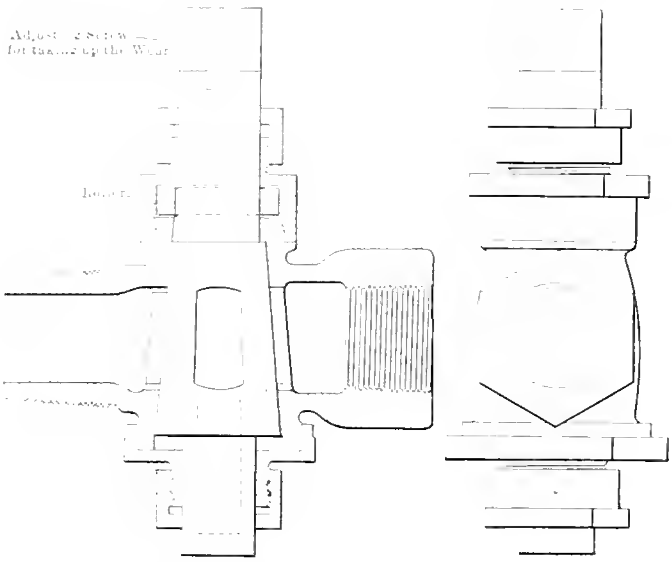
BALDWIN LOCOMOTIVE WORKS OUTPUT.—The number of locomotives built at the Baldwin Locomotive Works during the year 1906 was 2,652, of which 201 were electric and 2,451 steam; 281 locomotives were exported, the remainder being for domestic service. Of the 2,451 steam locomotives, 133 were equipped with compound cylinders. This is the largest output ever attained at these works, the figures for the three previous years being 2,022, 1,485 and 2,250, respectively. The number of men now employed at these works, exclusive of the Standard Steel Works, is about 19,000, and the number of working days last year was 307. Mr. George Burnham Jr., retired from the partnership on Dec. 31, 1906.

THE GREATER SAFETY OF ALCOHOL as compared with gasoline for commercial uses is due to the fact that it will not ignite from pure radiated heat as gasoline does; that water will extinguish burning alcohol while it will only spread a fire of gasoline, and that the flame of burning alcohol radiates very little heat while that of gasoline radiates heat very rapidly.

AUTOMATIC STOKERS.—It is difficult to obtain firemen who can stand the very severe labor connected with the very large passenger and freight engines. An automatic stoker is absolutely necessary to enable the railroads to secure a better grade of men for the position of fireman.—*A. B. & A. Official, in Railroad Men.*

ANDERSON LOCOMOTIVE BLOW-OFF COCK.

The Anderson blow-off cock, illustrated herewith, has several valuable and unique features. The plug is balanced and held in place by a patented roller locking device. This device consists of a rectangular piece of steel, which passes through the stem of the valve, and has journals at each end for the two rollers shown in the illustration. These rollers



ANDERSON LOCOMOTIVE BLOW-OFF COCK.

travel on incline planes, so that the valve is forced firmly to its seat when in a closed or open position. The adjusting screw takes up all wear. The valve can instantly be locked in neither an open or closed position. These features not only make the blow-off cock more satisfactory in operating, but add to its durability. They are manufactured by the Golden Anderson Valve Specialty Company, Pittsburgh, Pa.

INITIATIVE NECESSARY FOR SUCCESS.—A powerful initiative is inseparable from business ability. To conduct a railroad requires the same business attributes, from the stockholders' president to the gang boss, and no less, as to keep affoat a colossal industry on its by-products. The forceful men who have mastered these attributes find remunerative positions on every hand, ready to step into.—*Paul R. Brooks, before the New York Railroad Club.*

PERSONALS.

Mr. A. R. Ayers has been appointed supt. of shops of the L. S. & M. S. Ry. at Elkhart, Ind.

Mr. R. H. Rutherford has been appointed master mechanic of the Torreon division of the Mex. Cent. Ry.

Mr. M. Wesley Burke has been appointed general foreman of the Baltimore & Ohio R. R. at Garrett, Ind.

Mr. G. R. Ingersoll has been appointed purchasing agent of the L. S. & M. S. Ry., with headquarters at Cleveland, O.

Mr. J. T. Carroll has been appointed asst. supt. of shops of the L. S. & M. S. Ry. at Collinwood, O., vice Mr. R. D. Fildes, resigned.

Mr. J. W. Marden has been appointed supt. of the car department of the Boston & Maine R. R., with office in the Union Station, Boston.

Mr. Amenzo M. Carroll has been appointed asst. master mechanic of the Mohawk division of the N. Y. C. & H. R. R. R. at West Albany, N. Y.

Mr. Charles A. Bingham has been appointed engineer of tests of the P. & R. Ry., with office at Reading, Pa.

Mr. W. E. Chester has resigned as general master mechanic of the Central of Georgia Ry. The position is abolished.

Mr. F. R. Cooper, formerly master mechanic of the Lehigh Valley R. R., has been appointed supt. of motive power of the South Buffalo Ry.

Mr. W. J. Haynen has been appointed supt. of shops of the Pere Marquette, with office at Grand Rapids, Mich., succeeding Mr. M. C. Gregory, resigned.

Mr. A. H. Gairns has been appointed master mechanic of the first division of the D. & R. G. R. R., with headquarters at Burnham shops, Denver, Col.

Mr. Edward Payson Bullard, president of the Bullard Machine Tool Company, Bridgeport, Conn., died in Braidentown, Fla., December 22, aged 65 years.

Mr. R. F. Jaynes, genl. shop foreman, has been appointed to the new office of master mechanic of the Lehigh & Hudson River Ry., with office at Warwick, N. Y.

Mr. Thomas B. Purves, Jr., has been appointed supt. of motive power of the Denver & Rio Grande Ry., with headquarters at Denver, Col., succeeding Mr. J. R. Groves.

Mr. George W. Wildin has resigned as superintendent of motive power of the Erie R. R., and accepted the position of asst. supt. of motive power of the Lehigh Valley R. R.

Mr. J. M. Fulton has been appointed master mechanic of the Chihuahua division of the Mex. Cent. Ry., with office at Chihuahua, Mex., succeeding Mr. R. H. Rutherford.

Mr. C. D. Pettis has resigned as supervisor of the car department of the 'Frisco to become connected with one of the enterprises of Mr. Charles M. Hewitt, of Chicago.

Mr. George Moll, heretofore road foreman of engines of the P. & R. Ry. at Phila., Pa., has been appointed master mechanic of the Reading and Harrisburg divisions.

Mr. Thomas J. Tonge has been appointed supt. of motive power and rolling stock, bridges, building and water service of the Santa Fe Central, with office at Estancia, N. M.

Mr. J. E. Cameron, heretofore master mechanic of the Atlanta, Birmingham & Atlantic R. R., has been appointed supt. of motive power, with headquarters at Waycross, Ga.

Mr. E. O. Shively, asst. div. master mechanic of the Wabash R. R. at Decatur, Ill., has been appointed genl. foreman of locomotives, and the former position has been abolished.

Mr. G. C. Gardner, heretofore asst. master mechanic of the P. R. R. at Trenton, N. J., has been appointed genl. foreman of all roundhouses and shops on the Belvidere division.

Mr. C. H. Wiggin has been appointed supt. of motive power of the Boston & Maine R. R. and will have charge of all motive power on the road, with office at Union Station, Boston.

Mr. Martin Bylander has been appointed acting genl. shop demonstrator of the U. P. R. R., with headquarters at Omaha, Neb., succeeding Mr. F. M. Titus, assigned to other duties.

Mr. John McGie, master mechanic of the C., R. I. & P. Ry. at Shawnee, Okla., has been appointed master mechanic of the Arkansas and Louisiana divisions, with office at Little Rock, Ark.

Mr. Albert McCready has been appointed road foreman of engines of the first and second districts of the Albuquerque division of the A., T. & S. F. (Coast Lines), vice Mr. James Englehart, resigned.

Mr. D. D. Briggs has been appointed master mechanic of the L. & N. R. R. at Montgomery, Ala., in place of Mr. Gifford.

Mr. C. Gifford has been appointed master mechanic of the L. & N. R. R. at Mobile, Ala., succeeding Mr. H. M. Minto.

Mr. E. T. James, who recently resigned as shop superintendent of the Lehigh Valley R. R., has been appointed master mechanic of the New York, New Haven & Hartford Ry., with office at New Haven, Conn.

Mr. Henry Bartlett has been appointed genl. supt. of the mechanical department of the Boston & Maine R. R. and will have charge of all of the company's rolling stock and its mechanical department, with office at Union Station, Boston.

Mr. C. M. Taylor, who recently resigned as mechl. supt. of the Western Grand division of the A., T. & S. F. Ry., has been appointed master mechanic of the Panhandle division of the C., R. I. & P. Ry. at Shawnee, Okla., succeeding Mr. McGie.

Mr. J. W. Small, heretofore master mechanic of the S. P. R. R. at Los Angeles, Cal., has been appointed supt. of motive power of the Arizona Eastern, the Arizona & Colorado, the Cananea Yaqui River & Pacific, the Maricopa & Phoenix & Salt River Valley and the Gila Valley Globe & Northern, with headquarters at Tucson, Ariz.

Mr. W. H. Hudson has resigned as general master mechanic of the Southern Ry. at Knoxville, Tenn., to accept the position of vice-president of the Georgia Locomotive Company, of Atlanta, Ga. Mr. Hudson has been connected with the Southern Ry. and its predecessor, the East Tennessee, Virginia & Georgia, almost continuously since 1882, when he began as a machinist.

Mr. F. H. Greene, heretofore purchasing agent of the L. S. & M. S. Ry., has been appointed general purchasing agent of all the New York Central lines, with headquarters at New York. Mr. Greene entered railway service in the year 1885 as clerk in the purchasing department of the Grand Trunk Railway, since which he has been consecutively to July, 1899, chief clerk of the general stores department of the Chicago & Northwestern, secretary to the supt. of motive power of the same road and traveling auditor, in charge of mail and supplies of the same road. In July, 1899, he went to the L. S. & M. S. Ry. as secretary to the supt. of motive power, and has been purchasing agent of that road and the Lake Erie & Western since Jan. 1, 1900.

Mr. John T. Chamberlain has resigned as master car builder of the Boston & Maine Railroad after many years of faithful service. Mr. Chamberlain is a native of Eckington, England, and was born May 21, 1849. He was educated in New York and began his railway career as an apprentice in the car shops of the Atlantic & Great Western R. R. in 1868. In 1870 he entered the service of the Boston & Albany at Allston, Mass., where he finished serving his time. He was foreman of the freight erecting and repair shops of that road in 1878, and from 1885 to 1888 was general foreman of the Allston shops. In 1888 he was made genl. supt. of the Burton Stock Car Company at Wichita, Kans. In 1890 he accepted a position as master car builder of the Boston & Maine, which he has held up to the present time. Mr. Chamberlain was president of the Master Car Builders' Association in 1901 and 1902.

BOOKS.

The Slide Rule. A Practical Manual. By C. N. Pickworth. 104 pages. 5 x 7¼. Cloth. Illustrated. Published by D. Van Nostrand Co., 23 Murray Street, New York. Price, $1.00.

This is the tenth edition of this valuable book, which has been substantially revised in many parts and contains much new matter relating to special instruments of recent introduction. It is the most complete and elaborate work on this subject that we have seen and a perusal of its pages will show an unsuspected broad field of computation in which the slide rule can be used to great advantage.

Self Propelled Vehicles. A Practical Illustrated Treatise on Automobiles. Fifth revised edition, entirely rewritten. By James E. Homans. 5¼ x 8½. Cloth. 600 pages. Thoroughly illustrated. Published by Theo. Audel & Co., 63 Fifth Avenue, New York. Price, $2.00.

This book is a very complete treatise on the modern automobile and has been thoroughly revised to date.

Boiler Water. By William Wallace Christy. 235 pages. 6 x 9. Cloth. 77 illustrations. Published by D. Van Nostrand Co., 23 Murray Street, New York. Price, $2.00.

The title page of this book contains two very trite remarks to the effect that, "A steam boiler is a steam generator not a kettle for chemical reaction" and, "The only compound to put into a boiler is pure water." The book itself deals most exhaustively with the subject of boiler water for both locomotive and stationary use. It gives a number of tables showing the analysis of water taken from all parts of the country and carefully explains the proper method of treating the different kinds for the desired results. It also explains what results are desirable and what permissible. Taken altogether we can recommend this book most highly to any one interested in the water purification problem.

The Engineering Index. Edited by H. H. Suplee and J. H. Cuntz in cooperation with C. B. Going. Volume IV. 1901 to 1905. 1234 pages. 6½ x 9. Cloth. Published by the Engineering Magazine, 140 Nassau Street, New York. Price, $7.50.

This is the fourth volume of this very valuable work and covers the period from the year 1900 to the first of the year 1906. It covers all branches of engineering and clearly indexes and describes about 43,000 important articles and papers of permanent value which appeared in about 250 standard technical weekly, monthly and periodical journals., transactions and proceedings. All of this matter is presented in alphabetical order by subjects and is arranged for convenient and rapid reference. All of the articles on any particular subject or branch of work are grouped together under the proper heading, making it of exceptional value for the study or investigation along certain particular lines. For instance, the section on the subject of locomotives covers 36 pages and includes about 1500 separate articles, each of which is sufficiently described to give a clear idea of its scope. This work will be found to be practically invaluable in the working library of every mechanical office and of every engineer.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

American Turret Lathe.—The Gisholt Machine Company, Madison, Wis., has sent out a small folder giving a general description of this lathe.

Railroad Water Service Specialties.—Descriptive literature from the Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburgh, Pa., concerning the Anderson automatic and counterbalanced valve, adapted for all pressures, and especially designed for use in connection with railroad standpipes and tank service. Also a description of the Anderson patent float valve for controlling the water level in tanks or reservoirs. This company also has an altitude valve for maintaining a uniform stage of water in a tank and doing away with tank fixtures.

Induction Motors.—The Allis-Chalmers Co., Milwaukee, Wis., is issuing bulletin No. 1040, which is a revised edition of the previous induction motor bulletin and is to be substituted for it in the loose leaf binder. The subject is handled in the same careful, complete, and at the same time concise, manner which characterizes the recent bulletins of this company. Matter is included on starting apparatus for polyphase induction motors and a few illustrations are given showing the application to pumps and other machinery.

Valves and Packing.—Jenkins Bros., 71 John St., New York, is issuing an attractive catalog and price list, which shows many different designs of practically all types of pressure controlling

and regulating valves, as well as the large variety of packings handled by this company. Each separate design or kind of both valves and packing is illustrated and accompanied by a table giving sizes in which it can be furnished and the corresponding prices. One section of the book gives the important dimensions of each different design by means of outlined drawings. A price list of separate parts is also included.

TEN-WHEEL LOCOMOTIVES.—The fifth of the series of pamphlets which is being issued by the American Locomotive Company has recently been published. This pamphlet is devoted to 10-wheel type locomotives weighing less than 150,000 pounds, and will be followed shortly by another presenting the heavier designs of this type. The pamphlet illustrates and describes 21 different designs of 10-wheel locomotives ranging in weight from 64,000 to 150,000 pounds and adapted to a variety of road and service conditions. This series now includes pamphlets on the Atlantic, Pacific, Consolidation and 10-wheel types.

EMERY WHEELS AND GRINDING MACHINERY.—The Bridgeport Safety Emery Wheel Company, Bridgeport, Conn., is issuing an attractive catalog descriptive of grinding and polishing machinery, as well as the abrasive wheels for use thereon, which shows a very complete collection of different designs of this class of machinery. Tool grinders in many sizes for driving either by belt or motor, using either alternating or direct current, in both floor and bench designs, with one or two wheels, are very completely illustrated. Following these are many different arrangements and sizes of buffing lathes, as well as knife grinders in practically all sizes. Guide bar grinders, swinging frame grinders and other special designs are also included.

ELECTRICAL MACHINERY.—The General Electric Company issues under date of December, 1906, bulletins for binding in its loose leaf binder as follows: No. 4480, pipe thawing transformers; Bulletin No. 4469, which supersedes No. 4378, on pocket instruments for direct or alternating current; No. 4477, which supersedes No. 4226, on accessible manhole junction boxes; No. 4483, on automatic time switches; No. 4476 on type PP dial controllers; No. 4479, a complete description of the electrical equipment of the Toledo & Chicago Interurban Single Phase Railway, by John R. Hewitt; No. 4478, which supersedes No. 7360, on parts of type K series parallel controllers. These bulletins correspond in arrangement and scope to the previous issues of this character.

AIR AND GAS COMPRESSORS.—The Ingersoll Rand Company, 11 Broadway, New York, is issuing catalog No. 36 which confines itself to the subject of the Ingersoll-Sergeant air and gas compressors. These are made in nine classes, each of which is briefly described, accompanied by tables of sizes and illustrations of typical machines. In addition to being a very nicely arranged and well appearing catalog this book also contains much valuable engineering data for use in connection with air compressors, as well as two important articles, one on "Elements of Economy in the Straight Line and Duplex Types of Compound Air Compressors," which handles the subject in a very clear and convincing manner, and the other on "Compound Air Compression," which goes very deeply into the details of this subject. It contains 183 pages and will be found to be both interesting and valuable to all users of compressed air.

CALENDARS FOR 1907.—We beg to acknowledge receipt of attractive calendars as follows: From the Kennicott Water Softening Company a calendar which gives an excellent reproduction of Anglo Asti's famous painting "Thelma." This was one of the last and the greatest effort of this famous painter and was purchased by the late Charles Fair of San Francisco for $10,000. It is exceedingly fortunate that this reproduction was made before the catastrophe of last April, as the original painting was destroyed at that time.

The Crocker Wheeler Company is issuing a calendar showing a view, printed in colors, of the main office and works of the company. It is an excellent example of lithographic work and gives an impression of the magnitude and attractive surroundings of the Crocker-Wheeler works.

The Bangor & Aroostook Railroad is issuing calendars which include some very attractive reproductions, in colors, of camping scenes in the Maine woods. This company also publishes an interesting combined pamphlet and time table, which is profusely illustrated with scenes of points reached by its lines.

American Wood Working Machinery Co. is issuing a calendar in which the dates are in large numbers and each monthly sheet gives illustrations of different machines, totaling over 120, which are manufactured by it.

NOTES.

NATHAN MFG. CO.—This company announces that Mr. Charles R. Kearns, after an enforced absence of six years, due to illness, has again resumed his duties with it.

STANDARD COUPLER COMPANY.—Mr. George A. Post, Jr., has resigned his position as sales engineer with the Westinghouse Machine Company and accepted service as engineer representative of the Standard Coupler Company, 160 Broadway, New York.

RIEHLE BROS. TESTING MACHINE CO.—This company has been awarded the contract for a compression testing machine of 1,000,000 lbs. capacity for the Bureau of Surveys of the City of Philadelphia. It is to be installed in the testing laboratory of that city and will be used in making compression tests of building material, concrete, etc.

LOCOMOTIVE APPLIANCE COMPANY.—The election of officers of this company recently held, resulted as follows: Ira C. Hubbell, president; J. B. Allfree, consulting engineer; Clarence W. Howard, W. J. McBride and F. W. Furry, vice-presidents; and W. H. England, secretary and treasurer. This company also announces that Mr. H. H. Newson has been appointed sales agent.

CHICAGO PNEUMATIC TOOL COMPANY.—Mr. J. W. Duntley, president of the above company, who returned a short time ago from his twenty-first trip to England and the Continent in the interest of the pneumatic tool business, has again sailed for Europe for the purpose of closing up several important contracts. Mr. Duntley reports that the pneumatic tool business is on the increase at all points abroad.

INDEPENDENT PNEUMATIC TOOL COMPANY.—This company has been compelled by its largely increasing business to purchase a large four story brick building adjoining its plant at Aurora, Ill., which will give approximately 100,000 sq. ft. of additional floor space. A large amount of the latest improved machinery will be installed therein and it is expected that the company will be able to double its output in the coming year.

HEATING AND VENTILATING.—Among the installations of heating and ventilating apparatus now being installed by the B. F. Sturtevant Co., Hyde Park, Mass., are round houses for the Missouri Pacific Railway at Wichita, Kans.; Chicago Great Western at Red Wing, Minn., and the Northern Pacific at Dupo, Ill. The same company is also installing similar apparatus in the Dunkirk shops of the American Locomotive Co.

S. F. BOWSER & CO.—This company on account of its large increase in business during the past year has found it necessary to open a branch office in New York City. This office is located at 299 Broadway, and is in charge of Mr. W. F. Hatmaker. The company has also found it necessary to increase its factory at Fort Wayne by 125 per cent.; to build a new factory at Toronto and to add over sixty salesmen to its selling force.

QUINCY-MANCHESTER-SARGENT CO.—Mr. Howard M. Post has accepted the position of advertising manager with the above company. Mr. Post has had long experience in the advertising business and is thoroughly conversant with all its branches. He leaves a similar position with the Kellogg Switchboard and Supply Co., of Chicago, which he has successfully handled for a number of years, during which time there was issued a large amount of very fine catalog work, notably a beautiful 175 page Spanish edition of a general catalog.

GENERAL ELECTRIC COMPANY.—Mr. William J. Clark, general manager of the foreign department of the General Electric Company, has been appointed by Governor Hughes of New York as a delegate from that State to the National Convention for the Extension of Foreign Commerce of the United States, which will be held at Washington beginning January 14. Mr. Clark is thoroughly conversant with commercial conditions both at home and abroad and his book "Commercial Cuba" is recognized as an authority on the subject. He was a United States delegate to the International Railway Congress in 1905.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

MARCH, 1907.

STEEL PASSENGER CAR.

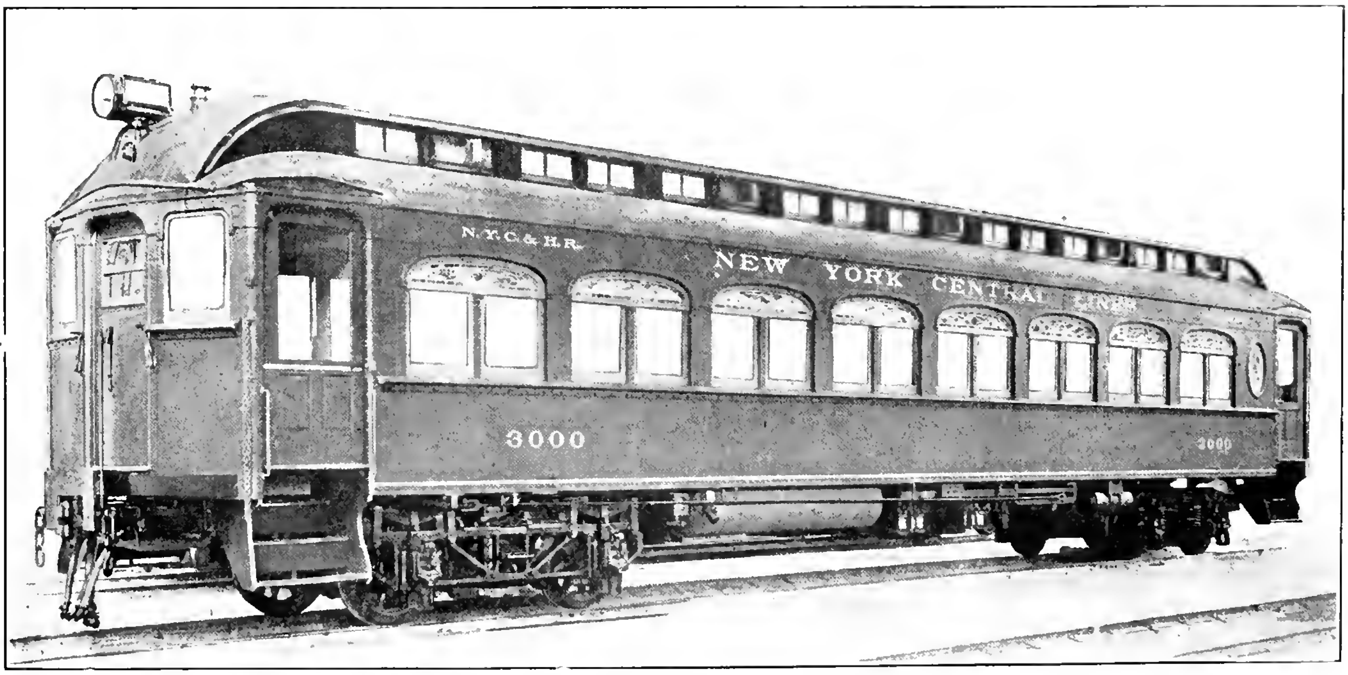
New York Central & Hudson River R. R.

In connection with the electrification of the Grand Central terminal, New York, the all steel type passenger car for use in suburban service was adopted by the New York Central and Hudson River R. R. One hundred and twenty-five of these cars have been built and delivered by the American Car & Foundry Company, and some of them have been in regular service during the past two months. The car bodies were designed by the American Car & Foundry Company, the railroad company's mechanical and electrical departments arranging the general floor plan of car and the layout of electrical apparatus, brake rigging and wiring. They are arranged for operation in trains by the multiple unit system, over the electrified section of the line, all of this order being motor cars. A later order of 55 cars of similar design, which will not be equipped with motors, has been made and is now being delivered.

These cars have the distinction of being the first non-inflammable passenger coaches ever constructed in this country for use on a steam railroad. Each car is mounted upon one motor and one trailer truck, the motor truck being fitted with two 200 h.p. motors driving each axle by means of gears. Both the motor and trailer trucks were thoroughly described and illustrated in this journal in the issue of May, 1906, page 166, and reference should be made to that description for the features of these very interesting all steel trucks.

The car body comes within the classification of "all steel," since the very slight amount of wood used is for fastening a portion of the interior finish and does not in any way enter into the framing or the structural part of the car. Furthermore all the inflammable material used has been thoroughly fireproofed and the wood is in all cases encased in metal, which prevents the possibility of splinters in case of a very improbable collapse of the body. The car measures 48 ft. $11\frac{5}{8}$ ins. in length inside of the body and is 60 ft. in length over the buffers. The height from rail to top of roof is 13 ft. $9\frac{1}{2}$ ins. The width over side sills is 9 ft. $8\frac{3}{4}$ ins.

The original idea when this project was first taken up was to build a car which could be operated through the subway of the Interborough Rapid Transit Company, connection to which could easily be made at the Grand Central Station, but it was found that such a car would be very restricted in clearance dimensions, and since these cars are operated over divisions up to 40 miles in length, it is necessary to provide more comfort and convenience than such restricted clearances would allow, hence the car built conforms in both clearances and appearance to the standard passenger car of the railroad. It is provided with toilet facilities, good ventilation, and the windows are so constructed that they can be raised to the full height, giving an unobstructed view to a seated passenger. The exterior of the car is painted the standard color, a deep olive green, and lettered and striped in gold to conform to the present passenger equipment. The interior has been painted a dark green relieved by gold and white stripes and light colored head lining.

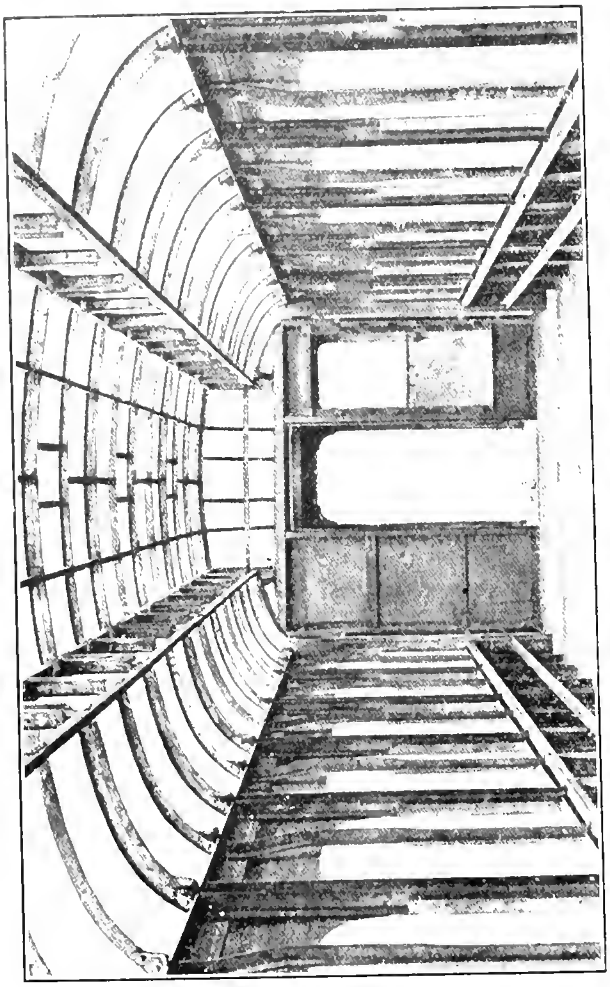


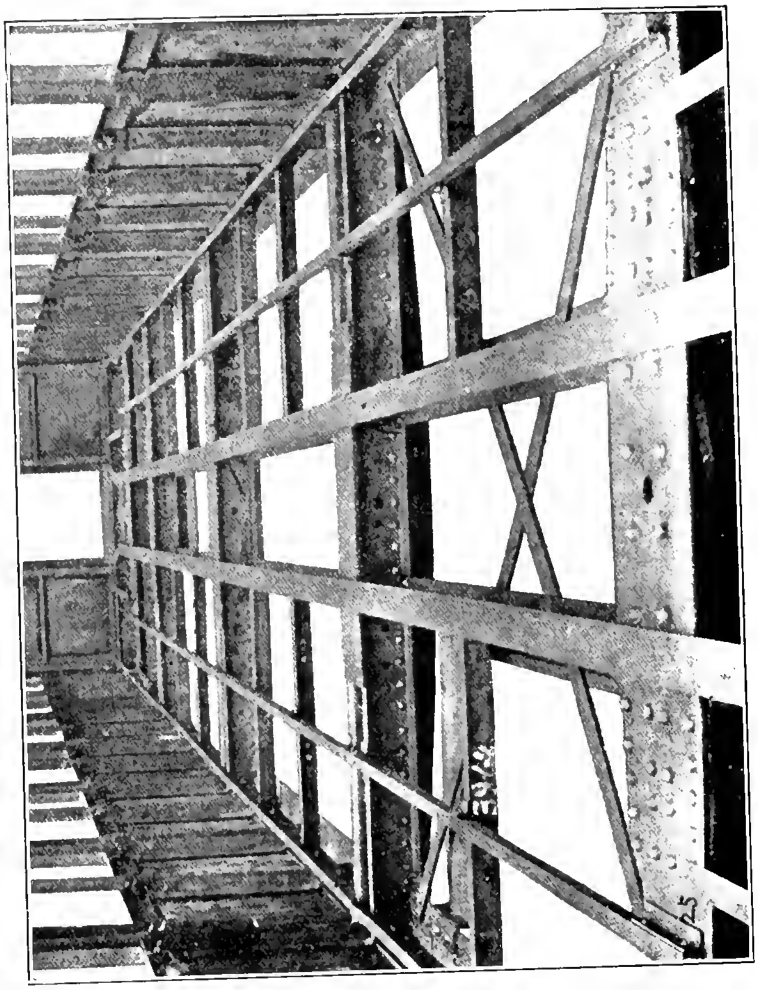
STEEL PASSENGER CAR—NEW YORK CENTRAL & HUDSON RIVER RAILR OAD.

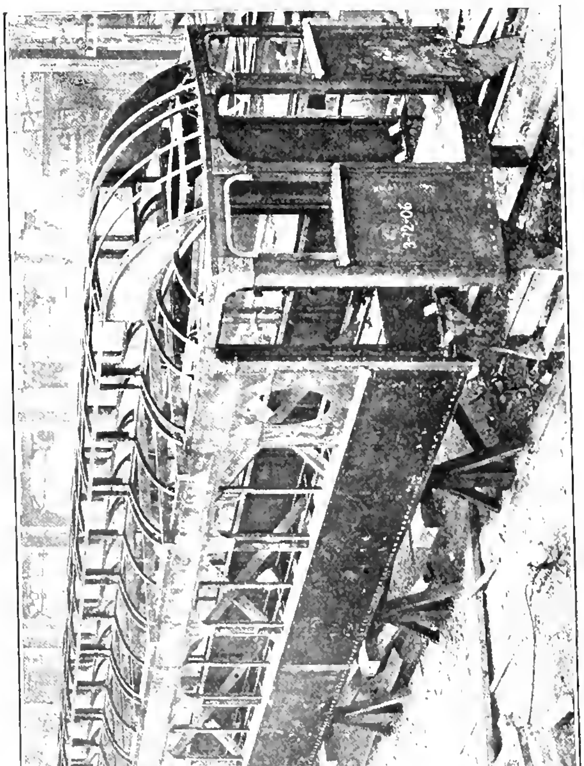
The wide vestibules have liberal dimensions length-wise, giving an unusually wide side door for the purpose of facilitating the loading and unloading of the car. The doors at the end of the car body are also made unusually wide for the same purpose. These cars will be operated in connection with raised platforms in some cases, and the vestibule trap door of pressed steel has been made to project below the side door, its outer edge being on a line with the side sheathing. Both the side doors and the end door in the car body slide into pockets suitably arranged, and the vestibule end door swings inward and incloses the motorman's control apparatus. A system of levers on the Pitt system permits the opening and closing of the side doors from a point between the cars outside the vestibules. Steps of steel provided with safety treads have been installed for use at stations where raised platforms have not been built.

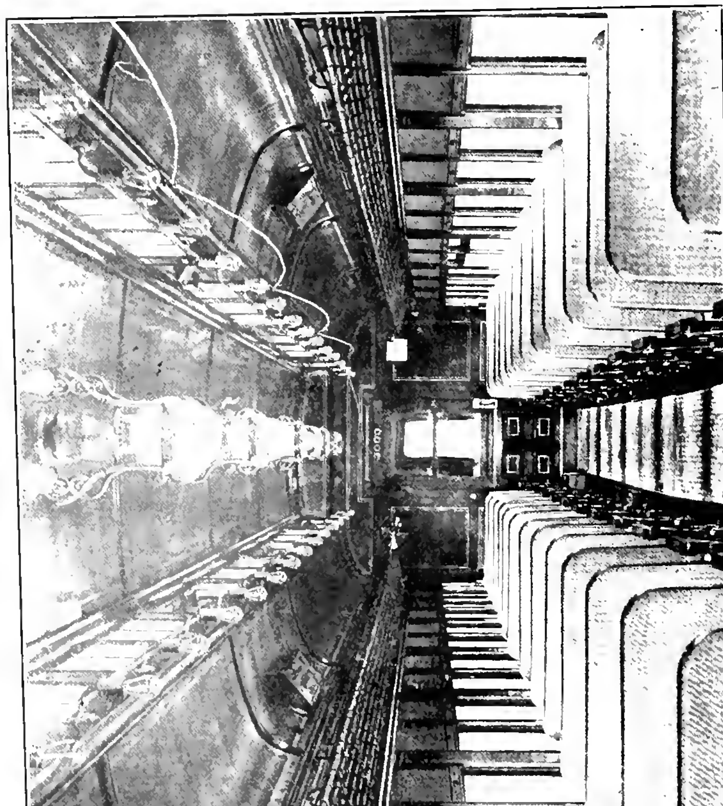
The illustrations show the construction so clearly that little additional description is required. The general scheme of con-

Steel passenger cars have been described and illustrated in this journal as follows: Illinois Central side-door suburban, Oct., 1903, pp. 358; New York Subway, all steel car, Oct., 1904, pp. 375; London Underground Ry., July, 1905, pp. 248; Southern Ry. (combination steel and wood), July, 1906, pp. 260; Long Island suburban car, Sept., 1906, pp. 340; Santa Fe postal car (steel underframe), Oct., 1906, pp. 397; Philadelphia Subway car, Nov., 1906, pp. 440; Harriman Lines steel coach, Jan., 1907, pp. 6; Long Island steel coach, Feb., 1907, pp. 40.

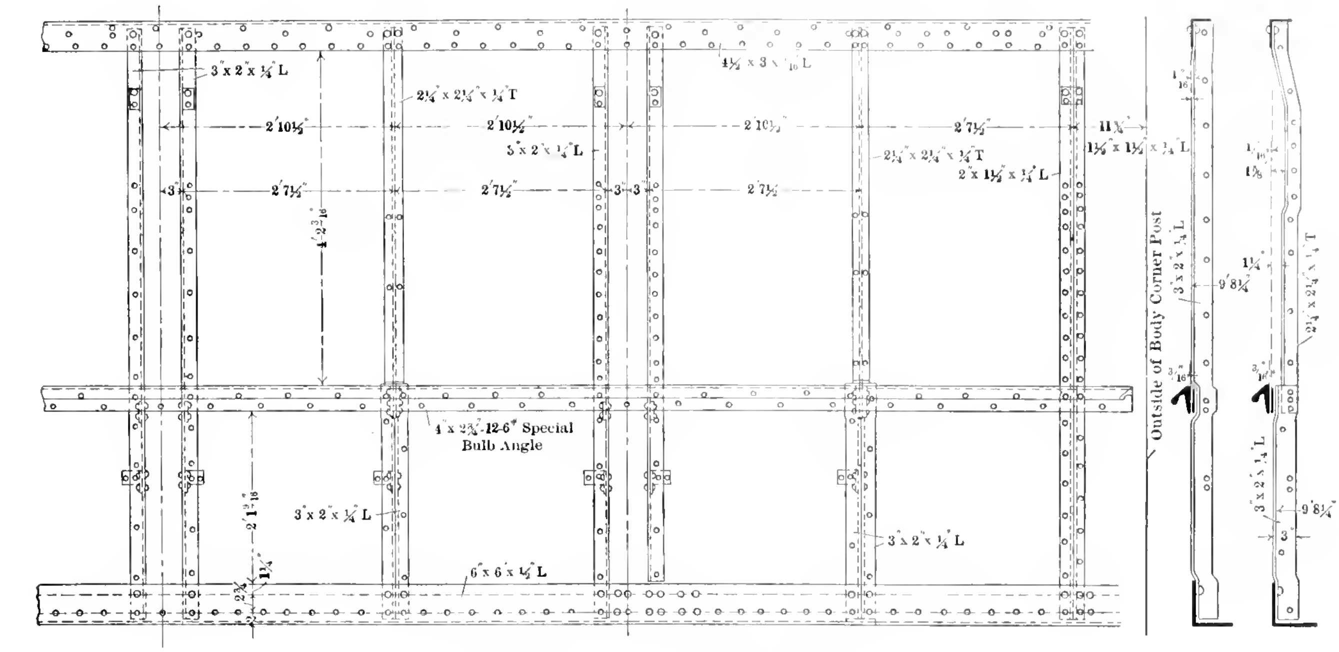








VIEWS OF FRAMING AND INTERIOR OF STEEL PASSENGER CAR—NEW YORK CENTRAL & HUDSON RIVER RAILROAD.



SIDE FRAMING—NEW YORK CENTRAL STEEL CAR.

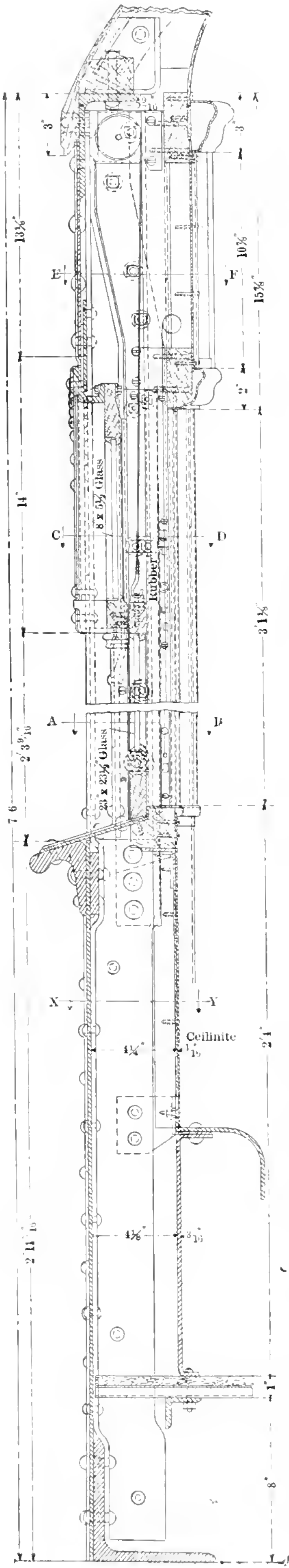
struction is the same as that of the Long Island steel coach designed and built by the same company, which was illustrated in the February issue of this journal, although it should be remembered that this is the earlier of the two designs. This scheme provides for the carrying of the whole load of the car body, including the underframe and the live load, by two plate girders, which form the sides of the car below the window sills. These are made up of a 3-16 in. web plate 36 ins. deep with a bottom or tension member consisting of a 6 x 6 in. angle which also acts as a side sill of the car. The top or compression member is in two parts, the outer one being a special 4 x 2¾ in. bulb angle and the inner a 7-16 x 3 in. bar. The girder is stiffened by the side posts of 3 x 2 in. angles, located in pairs about 34½ ins. apart and riveted to the web plate. These posts are off-set at the top and bottom of the girder to clear its upper and lower members. The web plate is made in three sections, the joint coming at the double 3 x 2 in. angles forming the cripple posts, where the plates are butt jointed and provided with a cover plate with sufficient rivets to make the joint of a strength equal to the solid plate.

The side posts consist in the case of the double piers of two 3 x 2 in. angles set 6 ins. apart extending from side sill to side plate and off-set as mentioned. In the case of the single posts which separate the two sashes of the double windows, they consist of the cripple posts of two angles set and riveted together and extending from the side sill to the belt rail, above which they are continued by a 2¼ x 2¼ in. T, carried to the side plate, the side plates being 4½ x 3 in. angles extending the full length of the car.

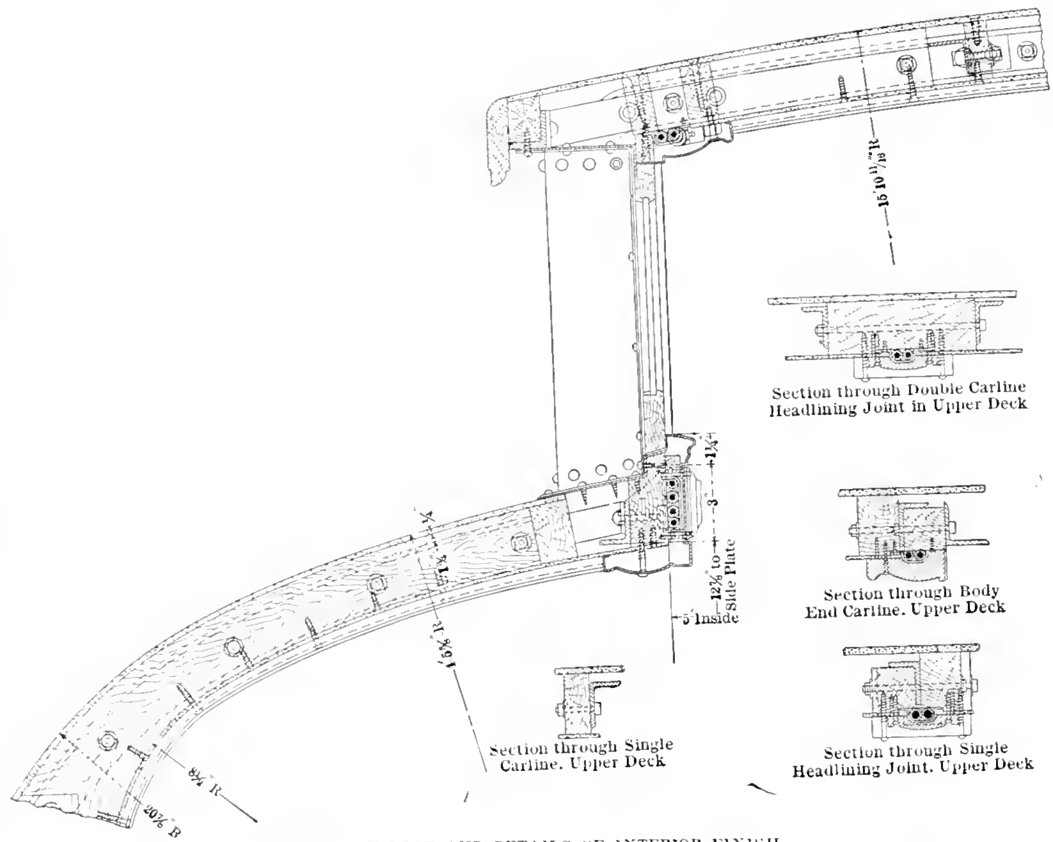
The carlines consist of 1¾ x 1¼ in. angles in one piece from side plate to side plate, being formed to the proper roof contour. There is a carline at the junction of each single side post, and two set 6 ins. apart at the junction of each double post, with the side plate. They are secured to the side plate by flanged corner angles. The carlines are spaced and stiffened by the purlines which consist of short sections of 1½ x 1½ in. angles set between the carlines and fastened by corner angles. The body end-carlines are double, being held together by rivets passing through spacing thimbles and the purlines and rafters not being continuous, this allows the removal of the vestibule roof in case of damage without disturbing the main parts of the body frame, the only continuous parts being the side plates and eaves angles. The vestibule roof construction includes two vertical ⅛ in. plates forming the sides of the clere story at this point, which being properly connected and stiffened, assist in carrying the weight of the platform and vestibule. The construction of the roof and vestibule is in its general features similar to that used on the Long Island car mentioned above, and reference can be made to the illustrations in that article for the basic features of this construction.

The underframe consists of two 8 in. 18 lb. I-beams set at 24 in. centres, continuous from buffer beam to buffer beam, which act as centre sills for taking the buffing and pulling strains. The weight of these, however, is transferred to the side girders by means of the cross bearers and they are not intended to support any of the weight of the car. They are turned out at an angle at either end for the purpose of giving clearance to the radial draft gear. The side sills are the 6 x 6 in. angles mentioned above as forming the lower part of the side girders. Auxiliary longitudinal or platform sills consisting of 8 in. channels extend from the junction of the centre sills and buffing beam back through the end sills and connect to the cast steel bolster. These platform sills, by means of the novel end sill construction and their special connection below the flange of the bolster are fulcrumed in the centre and prevent any sagging of the platform. The cross bearers, of which there are three between bolsters, consist of a trough-shaped pressed steel section passing below the centre sills and continuous between the side sills to which they are securely riveted. Special flanged filling pieces are set vertically at either edge of the trough section, extending between the side and centre sills; also similar pieces between the centre sills. A short cover plate passes through openings in the web of the centre sills and fastens to the top flanges of the filling pieces on either side. Since the filling pieces are also riveted to the sills and the flanges of the trough section the whole construction forms a box girder. The cover plate extends about 1-3 of the distance from the centre toward the side sills, which will allow it to be easily removed without disturbing the side sheathing. The underframing is further tied together and stiffened by two sets of diagonal ½ x 2½ in. bars connecting by gusset plates at the junction of the bolsters and cross bearers with the side sills. There are also diagonal members consisting of pressed steel channels between the ends of the bolsters and the junction of the end and centre sills. The end sills are made up of special flanged filling pieces set in pairs vertically between the centre and side sills and a malleable casting forming part of the draft gear arrangement between the centre sills. A channel which passes continuously below the centre and platform sills is turned up at either end between the flanged filling pieces and riveted to them.

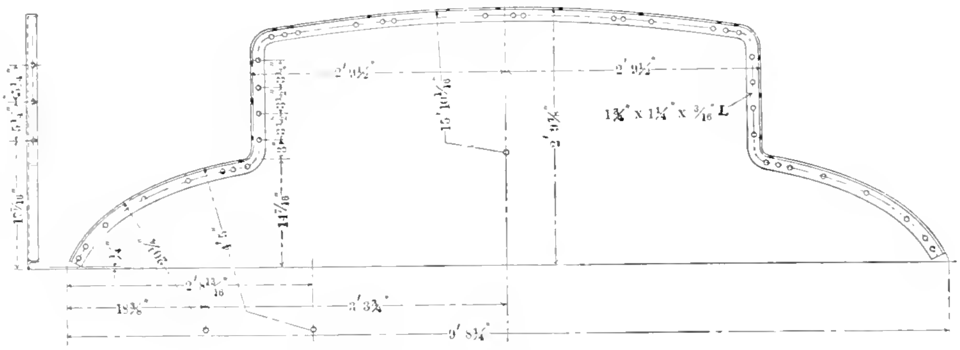
The bolsters are of cast steel of a special I-section design



SECTION OF SIDE.



SECTION OF ROOF AND DETAILS OF INTERIOR FINISH.

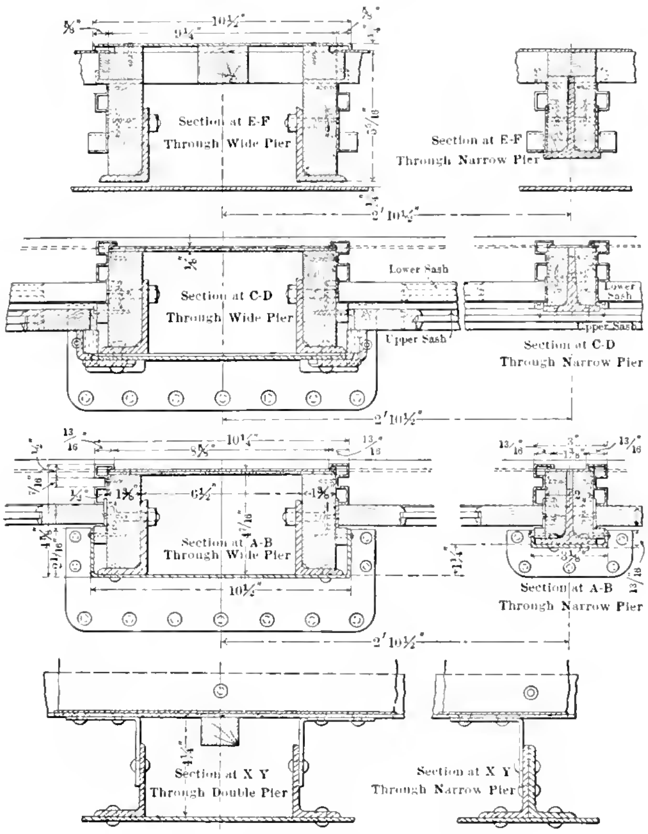


CARLINE—NEW YORK CENTRAL STEEL CAR.

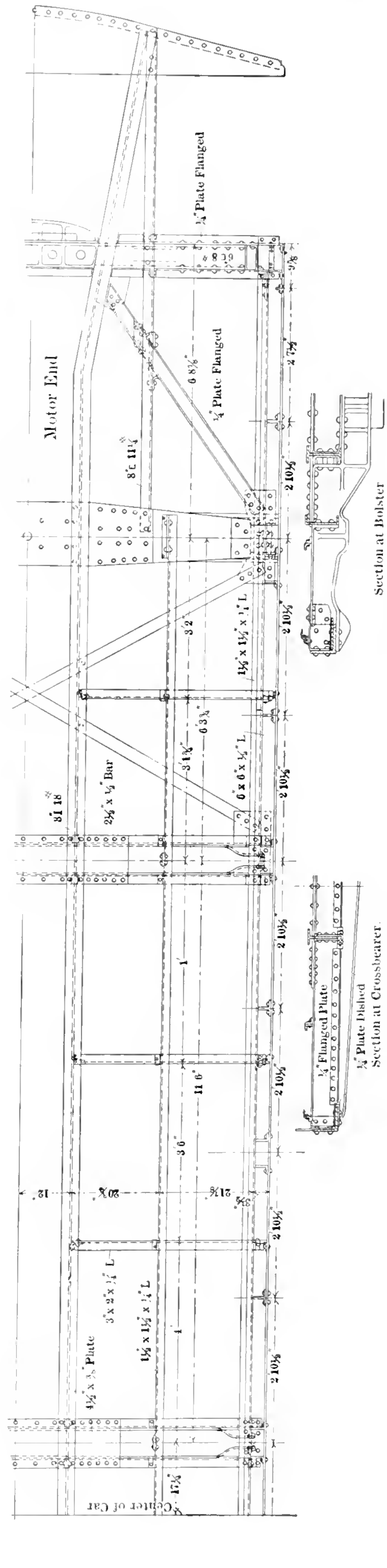
with a broad top. They are arranged to fit around the centre sills and include the centre plate. Lugs are provided for the fastening of the platform sills. Cast steel filling pieces are fitted between the centre sills and above the flange of the side sills and a heavy cover plate passing through the webs of the centre sills and riveted to the outstanding flanges of the bolster is provided. This cover plate is also of such a length that it can be removed without disturbing the side sheathing. The bolster is so constructed that it can easily be removed without disturbing the structural part of the car. These bolsters carry practically the whole weight of the car body and its load from the side girders directly to the trucks.

The floor is of "Acandolith" laid on corrugated steel sheets, which are supported by the centre sills and longitudinal floor angles resting on the cross bearers and bolsters. These longitudinal angles are further supported by the floor beams extending from centre to side sills, equally spaced between the cross bearers. The floor is finished by a tread of narrow wooden strips which are screwed in place and give a secure footing. These run longitudinally in the centre aisle and cross-wise between the seats. As will be noticed in the section of the under frame, there is a clear space of about 4 ins. between the floor and the cross bearers, bolsters, etc., which permits the convenient installing of electric wires, air brake piping, etc.

The draft gear is of the National Malleable Casting Company's truck actuated radial design, which will permit the cars to be coupled positively and without difficulty on a 135 ft. radius curve. With this arrangement the spring draft gear is placed between the centre sills about 3 ft. ahead of the bolster and from it the draw-bar extends outward and downward, connecting to the coupler on a level below the centre sills. The draw-bar is pivoted just ahead of the draft gear and has a connection on either side to the corners of the truck frame: this connection has double ball joints and is fitted with springs and follower plates in such a manner that as the truck swings it will carry the draw-bar and coupler with it, always keeping the draw-bar exactly tangent to the curve.



SECTIONS OF SIDE POSTS.

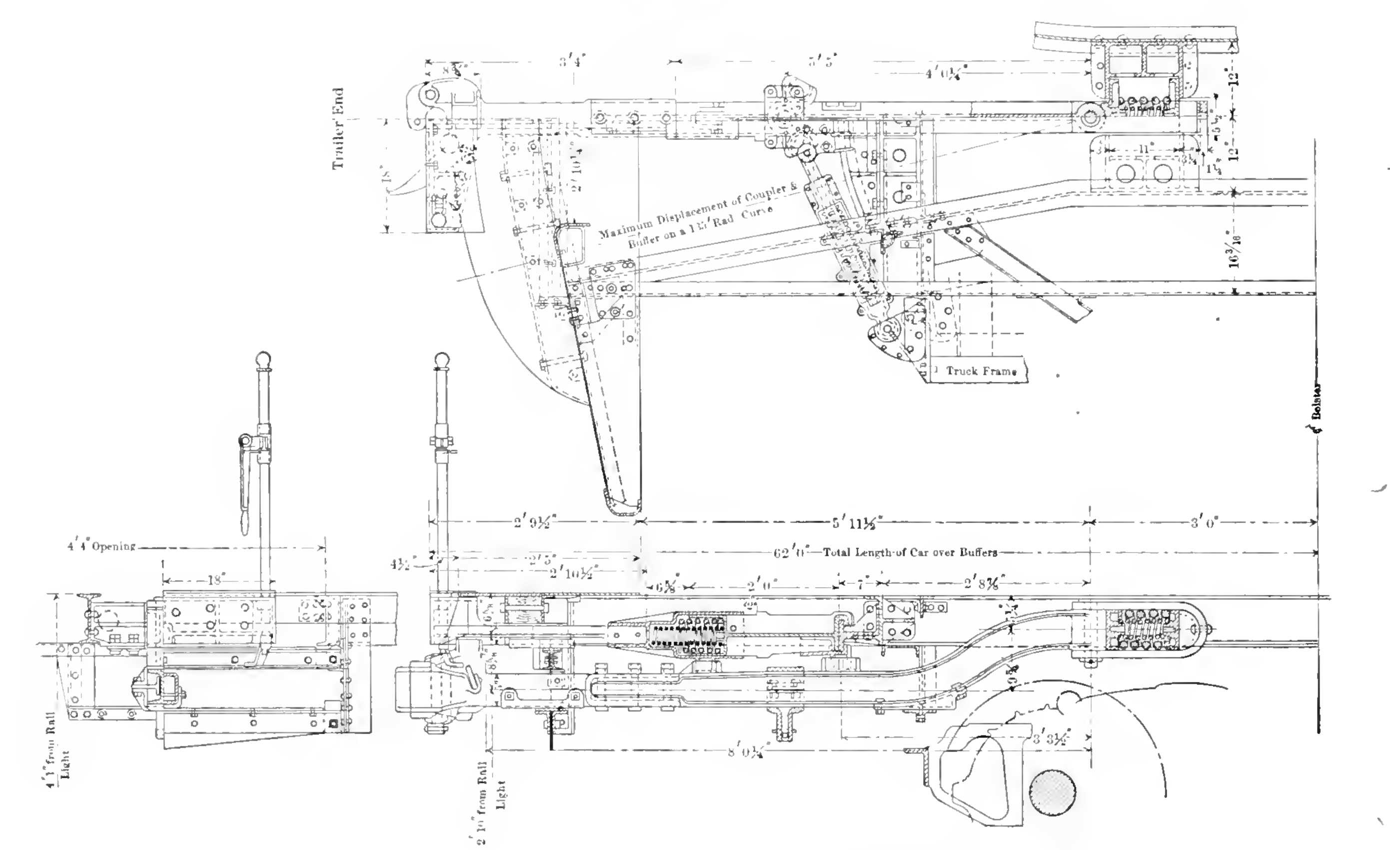


UNDERFRAME—NEW YORK CENTRAL STEEL PASSENGER CAR.

However, since the connection is made through springs any slight unusual movement of the coupler will not affect the truck. The air and steam hose are carried from the draw head and take the same movement. The spring buffer is also pivoted and connects to the draw-bar by a cast steel lug set in a pocket, so that it will take the same movement as the coupler and thus the buffing strains after passing the capacity of the spring buffer will be transferred to the draw-bar and thence to the centre sills. The whole arrangement is supported and secured to guides as shown in the detailed illustration.

The interior of the car is finished largely by drawn steel moldings and specially rolled steel plates. The head lining is of "Durite," which is a special artificial wood, as is also the outside of the roof, in the latter case being covered with painted canvas with copper flashings at the hips and eaves. The seats are of rattan, fireproofed, and fitted to steel frames, being of the "walk-over" type furnished by the Hale & Kilburn Company. The deck windows are of art glass and Automatic Ventilators to the number of four on either side of the clere-story and two in the saloons have been provided. The car is equipped for both electric and Pintsch gas lighting and has both electric and steam heating. The Pintsch gas chandeliers are located in the centre of the roof and the incandescent lights to the number of 30 along the edge of the deck in addition to 12 in pairs between the gas lamps. The electric heaters are placed beneath the seats and the steam heat pipes are placed along the side of the car in the usual manner. This double arrangement of heating and lighting is necessary since the cars will be operated over lines not yet electrified. An electric fan is placed just under the deck in each end of the car.

The motorman's control apparatus, which is located in the ends of the vestibules on the right side, consists of a Sprague General Electric master controller so arranged with a tripping device that if the motorman's hand leaves the handle the controller will spring to the off-position and at the same time give an emergency application of the brakes. This controller is situated for operation by the motorman's left hand and can be locked when not in use. Directly in front of the



TRUCK ACTUATED RADIAL DRAFT GEAR.—NEW YORK CENTRAL STEEL CAR.

motorman is the engineer's valve of the quick service Westinghouse brake system. He also has conveniently located a cord leading to an air whistle, and just behind him in the end bulkhead of the car is arranged a switchboard containing all of the switches and fuses necessary for operation from that end. This is closed and locked by a steel door. Each car is provided with an electric head light at either end located on the roof.

It will be noticed that there is an extension platform at the ends of the car outside of the vestibule which has been installed simply as a gangplank between the cars, made necessary by the large overhang of the radial coupler, which in turn is demanded by the sharp curves on which the car will be operated in the Grand Central station.

The car weighs 105,500 lbs. total, in running order. Of this the body of the car weighs 59,860 lbs. without electrical equipment and 67,200 lbs. with electrical equipment. The motor truck weighs 15,000 lbs. and the trailer truck 11,140 lbs., the weight of the motors alone being 12,160 lbs. for two, thus the car with one motor and one trailer truck but without motors or the electrical apparatus on the body would weigh 86,000 lbs. or about 1,344 lbs. per seated passenger, which compares very favorably with a modern substantially constructed wooden passenger coach.

The specialities in the car not previously mentioned are as follows: The Safety Car Heating & Lighting Co.'s Pintsch gas lighting, Gold Car Heating & Lighting Co.'s steam heat; Consolidated Railway Electric Light & Equipment Co.'s electric heaters. The hardware from Adams & Westlake Co. McCarthy continuous basket racks, Rostand Mfg. Co. The steel mouldings, Dahlstrom Metallic Door Co. The sash balances, National Lock Washer Co. Tower couplers, National Malleable Castings Co. Automatic ventilators, Automatic Ventilator Co. Safety treads, American-Mason Safety Tread Co. Door operating devices, Pitt Car Door Co. Curtains, Curtain Supply Co. The roof covering and head lining of "Durite," Indestructible Fibre Co. The "Celinite" for insulating the interior finishing, H. W. Johns-Manville Co. Signal lamps and brackets, Dressel Railway Lamp Works and thermometers, Parker Mfg. Co.

The general dimensions are as follows:

Length over buffers	60 ft. 0 ins.
Length inside body	48 ft. 11⅝ ins.
Width over side sills	9 ft. 8¼ ins.
Height, rail to top of roof	13 ft. 9½ ins.
Total weight in running order	105,500 lbs.
Weight of body	67,170 lbs.
Weight of body without electric equipment	59,860 lbs.
Weight of trucks—motor truck, 15,000 lbs., trailer truck	11,140 lbs.
Weight of motor and number per car	12,160 for two.
Weight of electrical apparatus without motors, included in body	7,340 lbs.
Seating capacity	64 passengers.
Number of saloons or toilet rooms	2.

Type of truck—Four-wheel motor truck, motor truck wheel base 7 ft. 0 in., 36-in. wheels; trailer truck wheel base 6 ft. 0 ins. and 33-in. wheels.

THE STORE AND SUPPLY DEPARTMENT.—If you will investigate fully you will find that the material issues of a railroad cover more than 45 per cent. of the entire operating expenses. As every one present knows, the subject of handling, storing and distributing this material is receiving more general attention by the executive officials than ever before. For the double reason of its magnitude and the nature of the operations in this department there lies an opportunity as in few others of a railway for causing disastrous waste, or effecting immediate and far reaching economies. Through poor management, carelessness, faulty judgment in our department there may be waste:

In money tied up.

In selection of poor material.

In lack of care, permitting shrinkage, etc., while in stock.

Through not ordering promptly, or just in advance of the need.

Through imperfect handling and delayed delivering.

In office work through inadequate system.

Unless these evils are prevented, or remedied, if they already exist, the work of the store and supply department will fall far short of the maximum efficiency.—*Mr. N. M. Rice, before the Railway Storekeepers' Association.*

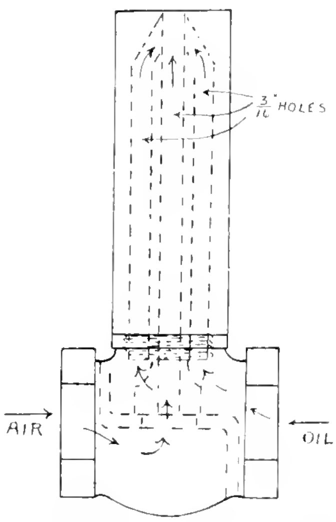
The total number of boiler explosions in 1906, as recorded by the Hartford Steam Boiler Inspection & Insurance Co., was 431 or 19 less than for 1905.

WELDING FRAMES WITH OIL.

BY C. J. MORRISON.

Broken frames have always been an item of considerable expense, and with the modern heavy engines this expense has assumed serious proportions.* Not only, under ordinary circumstances, does the repair of a broken frame require almost complete stripping of an engine, but it keeps it out of service from five to ten days, depending upon the shop facilities. A number of methods of welding the break without removing the frame from the engine have been tried. Probably the cheapest and best of these is that of heating the frames to the welding point by means of an oil torch. The details of making the weld differ in different shops, but the general method is the same.

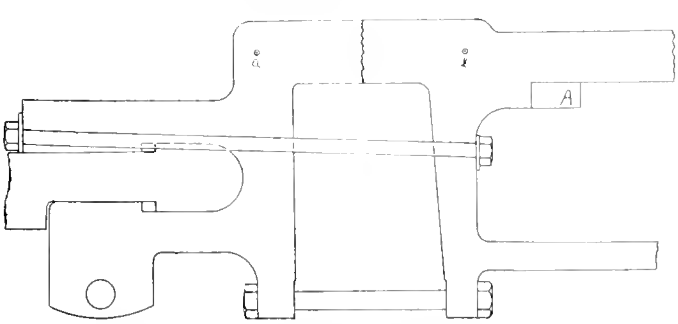
Crude oil is used and there are many designs of burners. One of the most successful is shown in the accompanying



OIL BURNER FOR WELDING FRAMES.

sketch. With this burner a 4 x 4 in. section can be brought to a welding heat in from forty-five to fifty minutes. The burner is a half inch globe valve with an atomizing attachment screwed in the top in place of the valve. Oil enters at one side of the valve and air at the other. The oil passes through the outside passages of the burner and the air through the centre one. The oil is fed by gravity from a tank holding about twenty gallons, which may be stood on the running board or any other convenient place. Air is used from the shop line and will give good results at pressures from 75 to 100 lbs. per sq. in. The oil and air pipes must have the valves about four feet from the burner so that the operator can handle them without being blistered by the heat. One burner will do for sections up to about 4½ x 4½ ins., but for sections larger than this it is advisable to use two burners, one on each side of the frame.

Different designs of frames and breaks in different sections will require a variation in the method of welding, but a description of the method used in welding a break over the front driving box on a heavy 2-6-2 type engine will probably make



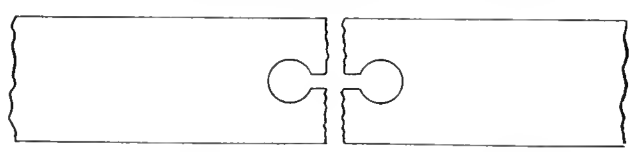
METHOD OF CLAMPING FRAME FOR WELDING.

the general method clear. The section at the break was 6 x 7 ins., or 42 sq. ins. The frame was held rigidly in place and with a tram, with arms about 18 ins. long to clear the furnace, punch marks *a-b* were made. A tram was also set to show the distance the jaws should be apart at the bottom. A jack was then placed in the jaws and the break was opened up. The bad iron (about ¼ in.) was chipped out with an air hammer. A piece of iron of slightly tapering section, ¾ of an inch thick at the centre, and measuring 6¼ x 7¼ ins. outside, was placed in the break. Heavy bolts were then placed across the jaws, as shown. The jack was slacked off and the bolts tightened up until the piece was held securely in place. A piece of iron ('A') 3 ins. wider than the frame was then bolted on the frame.

A furnace of fire brick and clay supported on a sheet of iron on horses was next built up around the break. The inside dimensions of the furnace at the break were 8 ins. long by 16 ins. high, so placed that the bottom of the furnace was 6 ins. below the frame and the sides 4 ins. each side of the break. The furnace tapered off from this size, at an angle of about 30 degs. with the frame, to two openings about 3 x 3 ins., one each side of the frame, level with the bottom of the furnace and 18 ins. from the frame. Just above the break a vent of similar size was left.

In building the furnace half bricks were placed, at a number of places, so that they could easily be removed, thus leaving openings through which the weld could be worked. Both burners were started and the frame heated up to the welding point. Borax was used freely as a flux. Several heavy blows were then struck at "A" with a ram and the bolts were drawn up until the tram showed the frame to be within 3/16 in. of its normal length. One burner at a time was then shut off and the weld was worked up with a heavy long stroke air hammer, using a bar three feet long placed through one and then another of the holes left for this purpose. Both burners were then extinguished, the furnace quickly knocked down and the weld trimmed up.

Another method that has proved successful where the section of the frame to be repaired is subject to severe up and down stresses was to drill two 2-in. holes, 4 ins. apart, one each side of the break and then on the centre line between the holes to drill ¾-in. holes. The frame was then spread until the centres of the 2-in. holes were 5 ins. apart. The bad iron in the break and the iron between the holes was chipped out with an air hammer, as shown in the sketch. A piece was then



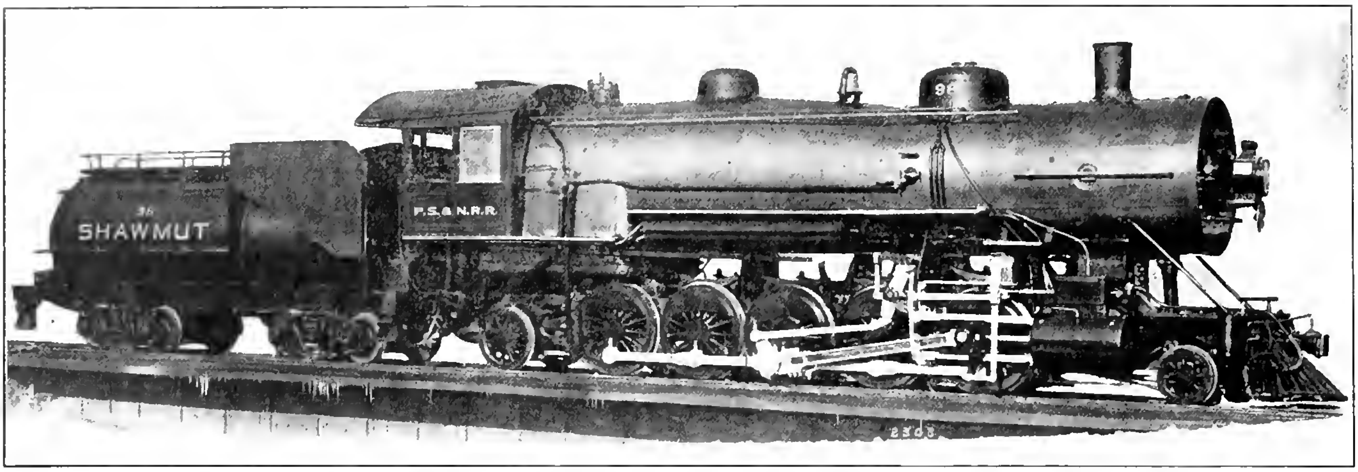
forged and machined to fit this opening and was driven in. Pieces were also put in the break on each side of the connecting piece and the weld was made as above.

One prominent shop shows the following cost of welding frames with oil:

Erecting shop	$16.41
Rod Work	6.09
Forge	16.44
Miscellaneous	3.78
Total	$42.72

This total cost is only a few dollars more than the actual cost of welding alone when the frame is taken down and sent to the forge.

PLANER VS. MILLING MACHINE.—To sum up, then, my belief is that where the simpler plane surfaces that naturally lend themselves to grouping are to be produced, the planer with a proper equipment is the natural machine to use, and will be found to give the lowest piece cost. It is understood, of course, that the piece cost when figured includes its proportionate share of fixed costs as it always should.—*Mr. H. P. Fairfield, in Machinery.*



SIMPLE FREIGHT LOCOMOTIVE WITH BALDWIN SUPERHEATER—P. S. & N. R. R.

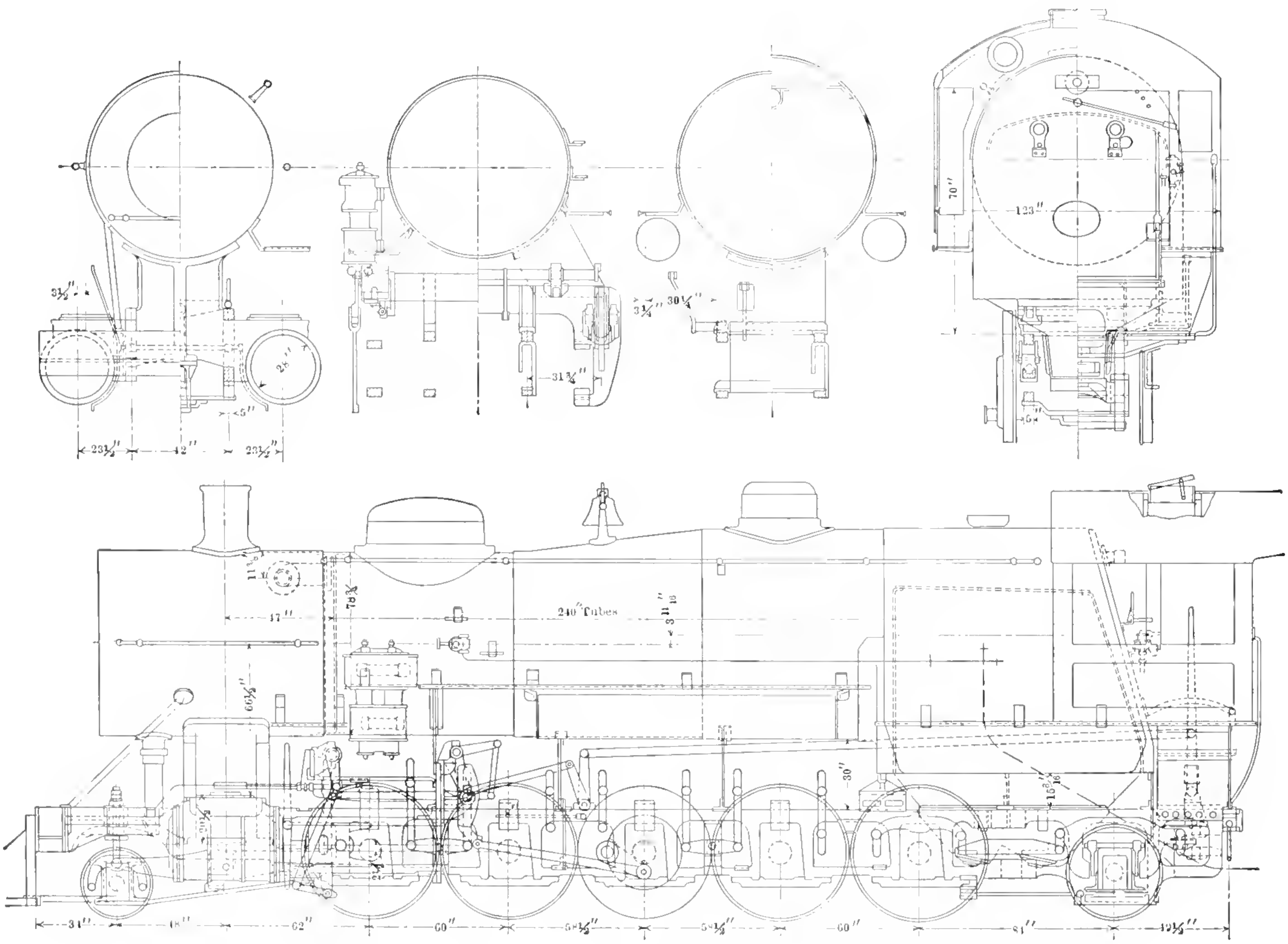
SANTA FE TYPE LOCOMOTIVE WITH SMOKEBOX SUPERHEATER.

PITTSBURG, SHAWMUT & NORTHERN RAILROAD.

The Baldwin Locomotive Works recently completed a very heavy simple 2-10-2 type locomotive, for the Pittsburg, Shawmut & Northern Railroad, which is illustrated herewith.

This locomotive is distinctive for a number of reasons. In the first place it is the thirtieth thousandth locomotive turned out from the Baldwin Locomotive Works; it is the heaviest simple locomotive ever built; it has the largest simple cylinders ever applied to a locomotive; it is equipped with a smokebox superheater of new design and it carries but 160 lbs. steam pressure. The locomotive in general size and appearance is very similar to the tandem compound locomotives, of which there are a large number in operation on the Atchison, Topeka & Santa Fe Railway. These were illustrated in this journal in 1903, pages 372 and 398; 1904, page 176. It exceeds those locomotives in total weight, but does not have quite as large a tractive effort.

The simple cylinders are equipped with slide valves, operated by the Walschaert valve gear. This arrangement of the valve gear has the combination lever on the outside of the guides, and in order to prevent the valve chest from exceeding the clearance limits the valve has been thrown 3½ ins. inside the center line of the cylinders and the connection to the gear is made through a rocker arm having both arms pointed downward and supported in bearings bolted to the cross tie, which in turn is supported on lugs cast in one piece

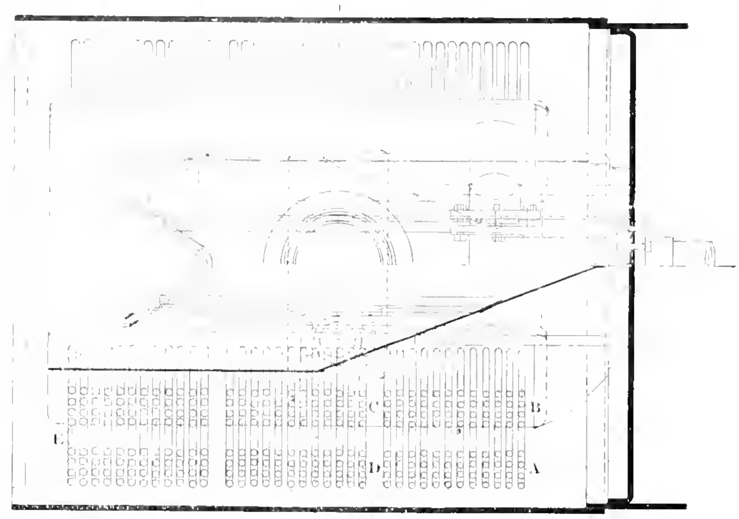


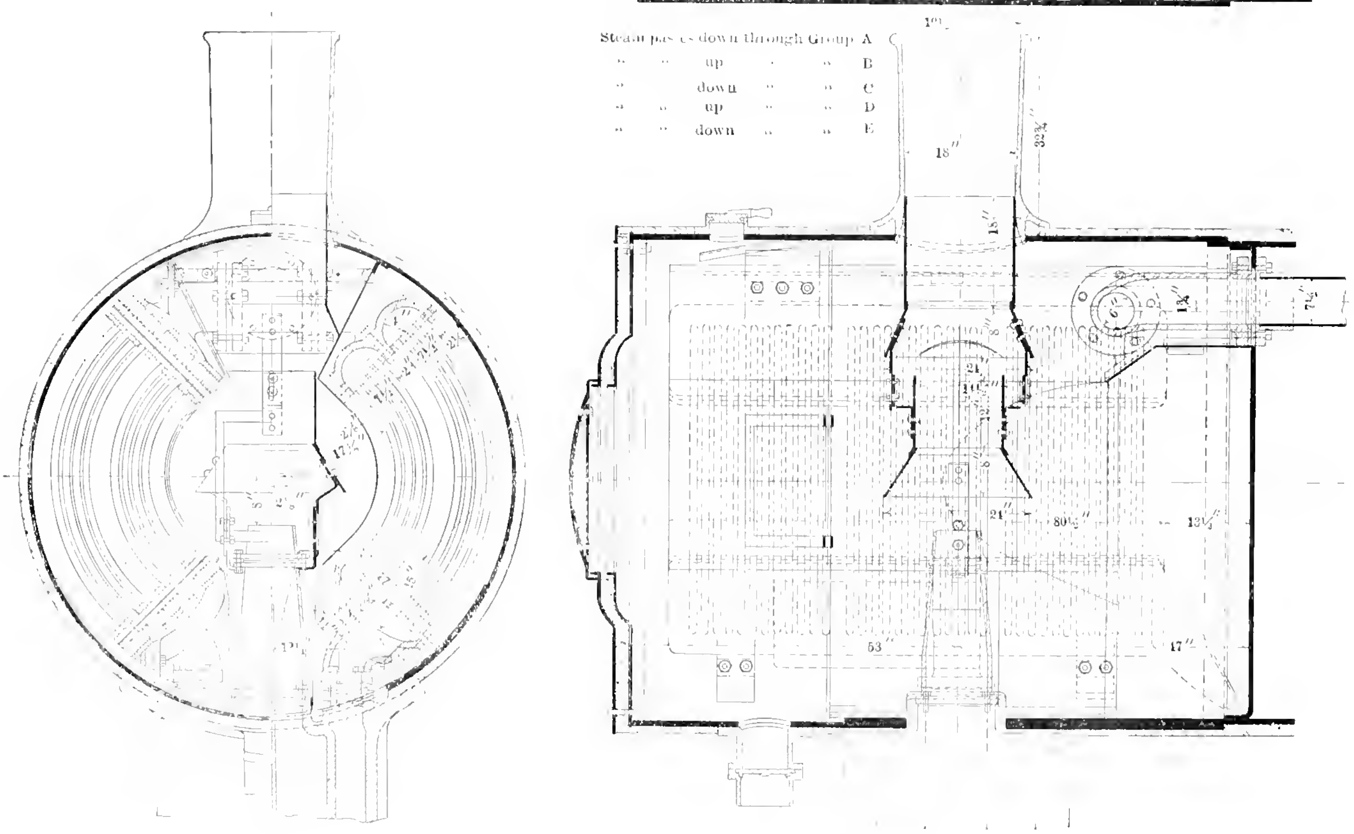
ELEVATIONS AND SECTIONS—SIMPLE FREIGHT LOCOMOTIVE WITH SUPERHEATER.

with the upper frame rail. The outer arm of the rocker shaft is connected to the combination lever and the inner one to the valve stem through a cross head connection.

The boiler is of the extended wagon top type, being 78¾ ins. in diameter at the front ring and 86 3/16 ins. at the dome course. The tubes are 20 ft. long and 2¼ ins. in diameter, there being 391 in the barrel. The cylinders, which are 28 ins. in diameter, with a 32-in. stroke, are the largest ever applied to a simple locomotive, and are equivalent to a 25 x 32-in. cylinder with 200 lbs. steam pressure. Each cylinder is cast with half of the saddle in the usual manner.

The point of greatest interest in this locomotive is the superheater which has been applied in the front end. Reference to the illustrations will show the design and arrangement of this device, and it will be readily noticed that this type of superheater does not interfere with the ordinary boiler, simply requiring an extended smokebox. It can be fitted to any locomotive now using saturated steam by the application of a new smokebox, and it can also be removed from any locomotive without interfering with its operation with saturated steam by simply replacing the superheater with the ordinary steam pipes. In brief, the superheater consists of two cast steel headers on either side which are cored with the proper passages and walls. These headers are connected by a large number of curving tubes, which follow the contour of the smokebox shell. The tubes are expanded in tube plates, and these plates are bolted to the headers. The curving tubes are divided into groups and the passages in the headers are so arranged that the steam after leaving the T head on either side passes down through the group forming the outer four rows of the rear section of superheater tubes, then crosses over in the lower header and passes up through the inner four rows of the same section, thence down through the inner group of the next section and up through the outer group, and thence down through both the inner and outer groups of the forward section and through a passage way in the lower header to the saddle. These tubes are heated by the gases from the fire tubes and the deflecting plates are so arranged as to compel these gases to circulate around the tubes on both sides to the front end of the smoke box and thence back through the center to the stack. Thus the superheater uses only such heat as is ordinarily wasted through the stack, and whatever gain in superheat is obtained is clear gain. Experiments so far made with this type of superheater show that while it is not possible to obtain a very high degree of superheat, enough is obtained to very decidedly increase the economy of the boiler. The front end is heavily lagged at all points to prevent, as far as possible, all loss of heat by radiation. The arrangement of the draft pipes, stack and exhaust nozzle is clearly shown in the illustration.





BALDWIN SUPERHEATER—P. S. & N. R. R. LOCOMOTIVE.

The general dimensions, weights and ratios of the locomotive are as follows:

GENERAL DATA

Gauge	4 ft. 8½ in.
Service	freight

Fuel	bituminous coal
Tractive effort	60,000 lbs.
Weight in working order, est	288,000 lbs.
Weight on drivers, est	235,000 lbs.
Weight of engine and tender in working order, est	450,000 lbs.
Wheel base, driving	19 ft. 9 in.
Wheel base, total	35 ft. 11 in.
Wheel base, engine and tender	67 ft. 4½ in.
RATIOS.	
Weight on drivers ÷ tractive effort	3.92
Total weight ÷ tractive effort	4.8
Tractive effort x diam. drivers ÷ heating surface	715
Total heating surface ÷ grate area	82
Firebox heating surface ÷ total heating surface, per cent	4.4
Total heating surface ÷ superheater heating surface	6.3
Tube heating surface ÷ superheater heating surface	6.
Weight on drivers ÷ total heating surface	49
Total weight ÷ total heating surface	60.3
Volume both cylinders	22.82 cu. ft.
Total heating surface ÷ vol. cylinders	216
Superheater heating surface ÷ vol. cylinders	33.4
Grate area ÷ vol. cylinders	2.57
CYLINDERS.	
Kind	Simple
Diameter and stroke	28x32 in.
Kind of valves	Bal. slide
WHEELS.	
Driving, diameter over tires	57 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	11x12 in.
Driving journals, others, diameter and length	10x12 in.
Engine truck wheels, diameter	29¼ in.
Engine truck, journals	6½x10½ in.
Trailing truck wheels, diameter	40 in.
Trailing truck, journals	7½x12 in.
BOILER.	
Style	E. W. T.
Working pressure	160 lbs.
Outside diameter of first ring	78¾ in.
Firebox, length and width	108x78 in.
Firebox plates, thickness	⅜ & 9-16 in.
Firebox, water space	F-4½, S-5, B-4 in.
Tubes, number and outside diameter	391-2¼ in.
Tubes, length	20 ft.
Heating surface, tubes	4,586 sq. ft.
Heating surface, firebox	210 sq ft.
Heating surface, total	4,796 sq. ft.
Superheater heating surface tubes	704 sq. ft.
Superheater heating surface, drums	58 sq. ft.
Superheater heating surface, total	762 sq. ft.
Grate area	58.5 sq. ft.
Smokestack, diameter	18 in.
Center of boiler above rail	118 in.
TENDER.	
Tank	Vanderbilt
Frame	Steel
Wheels, diameter	33 in.
Journals, diameter and length	5½x10 in.
Water capacity	8,500 gals.
Coal capacity	14 tons.

INSTRUCTIONS TO GOVERN THE USE OF COKE ON LOCOMOTIVES.

Mr. J. E. Muhlfeld, general superintendent of motive power of the Baltimore & Ohio Railroad, has issued the following instructions to govern the use of coke on the locomotives on that road. This is a subject that is of much importance as a possible solution of the smoke problem, particularly on those roads having freight terminals within the limits of large cities, and we are pleased to be able to publish these instructions at this time.

Coke should be of a hard quality, as free from dust as practicable, and of 48 or 72 hours' burning.

When coke is furnished from chutes to locomotive tenders the floor of the chute should be arranged as a screen so that the fine dust will be removed and not passed to the tender. The screen should be made of 1-in. round steel bars, spaced 1 in., and running longitudinally.

When coke is handled from a car into buckets from which it is to be supplied to the tender, ballast forks should be used for handling the coke when filling the buckets.

After the tender has been furnished with a supply of coke it should be thoroughly wet down to further eliminate the fine dust and carry it to the bottom of the tender, from which point it should be removed from time to time.

As a sharper blast is required for a coke fire, locomotives using coke as fuel should be equipped with exhaust nozzle openings about ¼ in. smaller in diameter than those for bituminous coal-burning locomotives.

Coke-burning locomotives should be equipped with finger style of rocking grates, in order to crush the clinker and to give better draft than can be secured with the bar types of rocking grates. The grate area should be as large as practicable and the rocking, dead and drop grates and operating gear should be kept in good adjustment to permit of free operation and without lost motion. As coke contains a much greater percentage of fixed carbon and ash than bituminous coal, it is very essential that the grate gear be maintained as above specified to insure against any difficulty of removing the ash and incombustible matter from the firebox.

Locomotives with large diameter and short flues will give the best results on account of remaining unobstructed and giving freer draft than smaller and longer flues.

Brick arches should not be used in fireboxes of coke-burning locomotives, as they interfere with maintaining the proper depth of fire. With coke a much heavier fire is required than with bituminous coal, as it does not pack so closely and there is liability for the introduction of cold air through the grates, which will lower the temperature of the gases and cause failures to steam.

The preparation of the coke fire must be given careful attention. Wood and semi-bituminous, low volatile soft coal should first be applied to the grates. This will assist in igniting the coke and preventing it from clinkering over the grate surface. After the coal has been thoroughly ignited the coke should be introduced until the firebox has been filled. The steam blower must be used until the coke is well burned through and makes a solid body of fire. The fire should then be left in this condition until the locomotive has commenced work and until 15 or 20 miles have been run; then at the first opportunity, preferably when steam is not being worked, the firebox should be filled with a fresh supply.

The fires should be cleaned after each 24 hours of service, and at the same time the flues should be blown out with the air blower equipment, that should be installed at each of the fire cleaning stations.

Engineers will be responsible for the proper operation of locomotives with respect to the handling of the reverse and throttle levers and to the supplying of feed water.

Engineers and firemen will be equally responsible for the operation of steam blowers and for the economical firing of locomotives, in accordance with the following general instructions:

Before the commencement of a trip or day's work the rocking and drop grates, ash pan dampers, ash pan slides and grate and ash pan operating gear should be examined and tested to see if all grates set level when latched, and that all parts are in good working order and proper position. The smokebox and ash pan should be clean and the smokestack and ash pan steam blowers in good order. All necessary fire tools, including a slash bar to prevent formation of clinker on grate surface, and scraper to remove the honeycomb that accumulates on the flue heads, must be on the locomotive. The fire must be put in good condition on the grates preparatory to starting, with a full supply of water and steam in the boiler. The coke on the tender should be wet down.

As heavy a fire should be kept on the grates as is necessary to prevent loss of heat, on account of cold air passing through the grates so freely as to reduce the temperature of the gases and to suit the way the locomotive is being operated. Fresh coke should be supplied to the firebox when the throttle is shut off. The use of the rake and puddling of the fire should be resorted to only when absolutely necessary to spread an uneven fire caused by uneven draft or improper firing.

The smokestack blower should not be operated any more than necessary, on account of coke burning out more quickly than coal, and when the ash commences to accumulate the blower will tend to draw cold air and ash into the flues instead of heat.

Rocking grates must be shaken lightly and frequently instead of violently at long intermittent periods, and, if possible, when steam is shut off. As a general rule, all rocking grates on passenger locomotives should be shaken every 20 miles; on freight locomotives every 10 miles, and on switching locomotives every hour. This practice will break any clinker that may be forming over or hardening between the

grate openings, and will allow dead ashes to fall into the ash pans and keep the grates and fire clean. It will also allow air to pass through the grates and fire and prevent the formation of clinker on the firebox flue and crown sheets, which occurs when air cannot get through the grates and must pass over the fire.

The practice of opening the furnace door unnecessarily should be avoided, and firemen must regulate the ash pan damper openings to suit all requirements. When locomotives are drifting the fires must be maintained in a clean and bright condition over the entire grate area, more especially at the flue sheet.

Hopper slides of ash pans must not be opened when the locomotive is running. Ash pans and fires should not be cleaned near any frog, switch, crossing, de-rail or wooden building or structure.

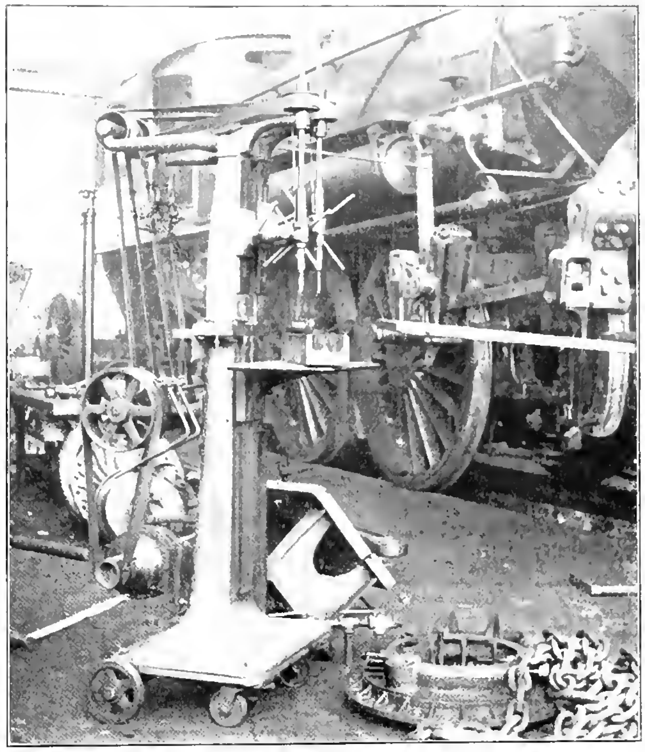
The above methods are those of the most successful firemen, and the highest type of fireman is one who can maintain the working steam pressure within a range of 10 lbs. variation with the smallest amount of fuel and the least waste of steam through the pop valves.

PORTABLE MACHINE TOOLS IN THE ERECTING SHOP.

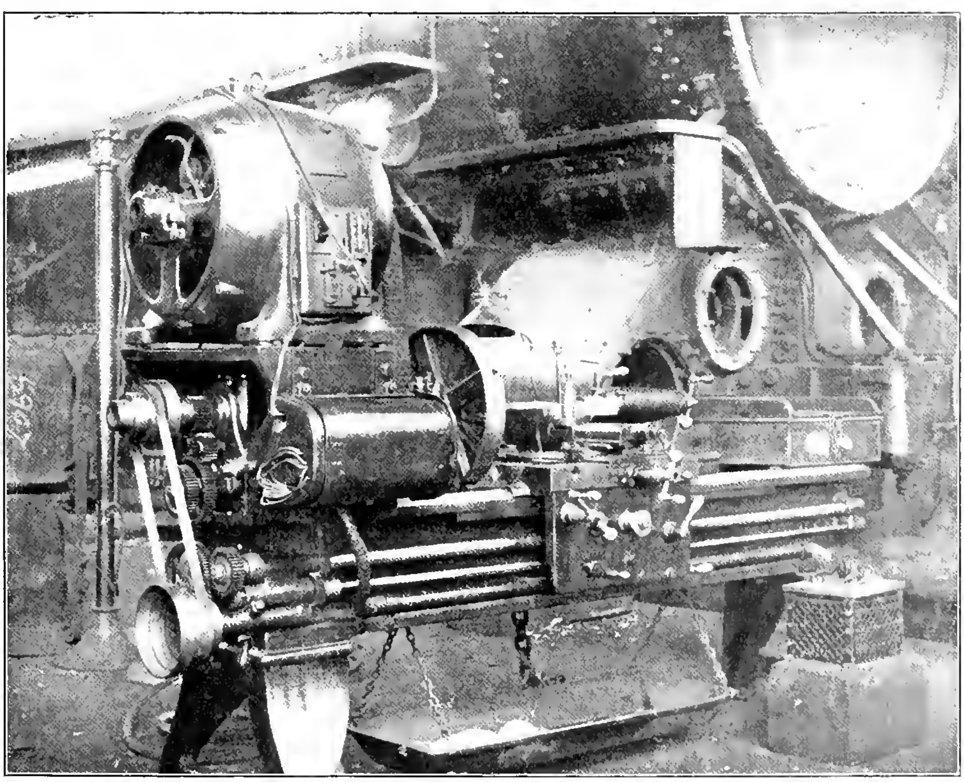
The two portable tools, illustrated herewith, are being used to very great advantage in the erecting shop of the Lake Shore & Michigan Southern Railway at Collinwood. Both of these tools are motor driven and receive current through flexible cords from stands or lamp-posts between the pits. These lamp-posts are arranged to take extension-cord plugs for portable incandescent lamps and also have a 25 ampere capacity extension plug receptacle from which flexible cords may be carried to any point to operate 5 h. p. motors. One of these lamp-posts is shown to the left of the lathe.

The two-spindle sensitive drill is mounted on rollers and can readily be transported over short distances on these, although for longer distances it is usually carried by the traveling crane. This drill is used almost entirely by the shoe and wedge machinists and effects a considerable time saving in this work.

The 18-in. lathe is used principally for turning cylinder, saddle and frame bolts. It is transported to different points on the erecting floor by the traveling crane. In lifting the lathe a hook is passed through the eye-bolt at the top of the motor and a chain is passed around the bed at the tail-stock end. The cast iron pan, suspended underneath the bed by chains, catches the greater part of the cuttings so as not to litter the floor. The electric light attached to the standard on the lathe carriage receives its current from the lamp-post. The lathe can quickly and easily be placed near an engine when the bolts are ready for fitting and the operator does not have to waste his time running back and forth between the machine and erecting shop.

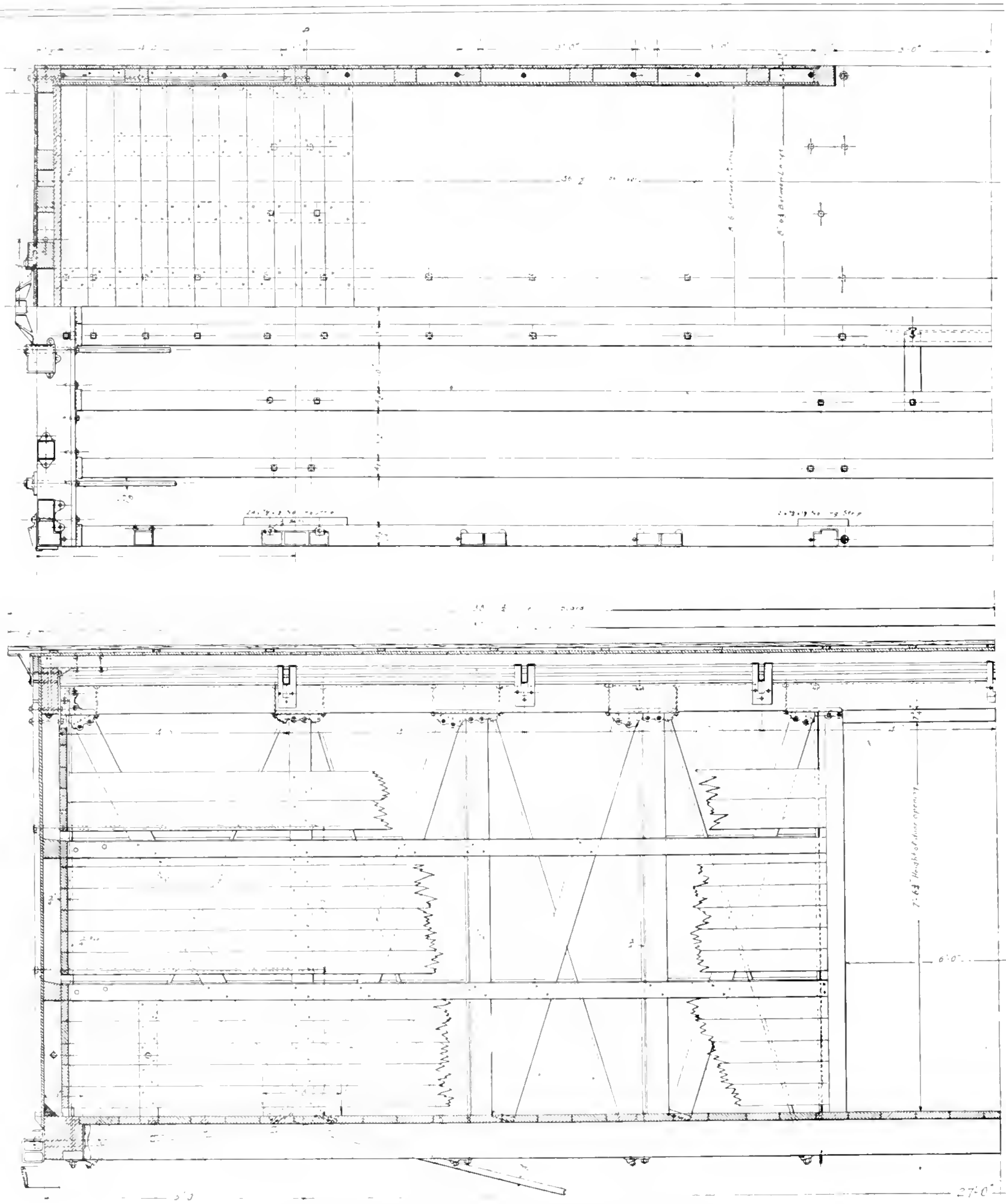


PORTABLE TWO SPINDLE DRILL IN ERECTING SHOP.



18-INCH LATHE IN ERECTING SHOP.

FUNCTION OF THE TOOL ROOM.—In a broad sense it has been said that the prime function of the tool room is to act in the capacity of an arsenal to provide the management with the necessary weapons to wage war upon excessive cost; the word "excessive" is here used to indicate any excess of cost beyond that minimum at which it is possible to produce the article to be manufactured. Now and then a master mechanic tells us he has built and repaired engines without having any tool room connected with the shop. In days gone by, successful battles were fought with clubs, bows and arrows; but what chances would these same armies stand with a modern army equipped with modern weapons? An aim of every superintendent of motive power is to obtain the most extensive output possible at the lowest cost, and the tool room is perhaps the most important factor in bringing about such a result.—*Mr. H. W. Jacobs in the Engineering Magazine.*



STANDARD BOX CAR—NEW YORK CENTRAL LINES.

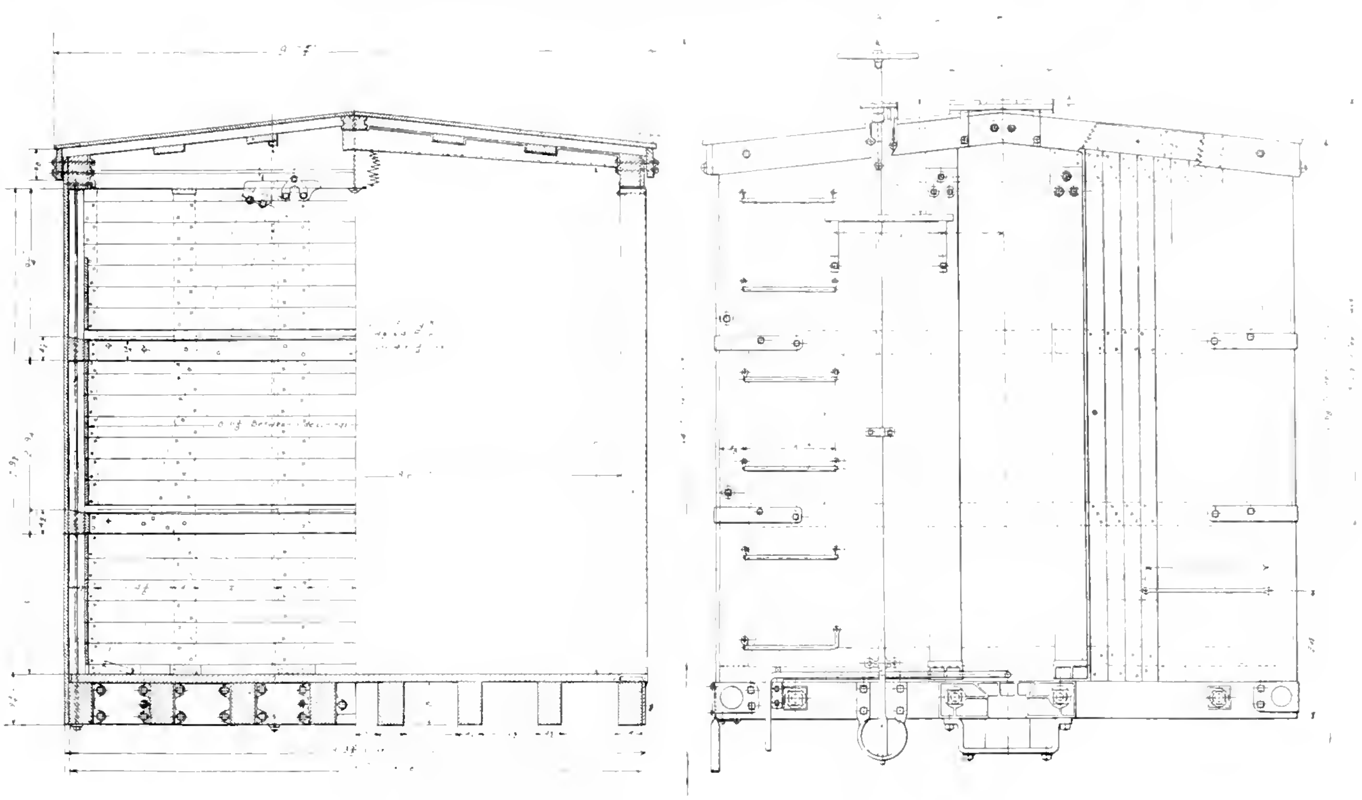
STANDARD 40-TON BOX CAR.

NEW YORK CENTRAL LINES.

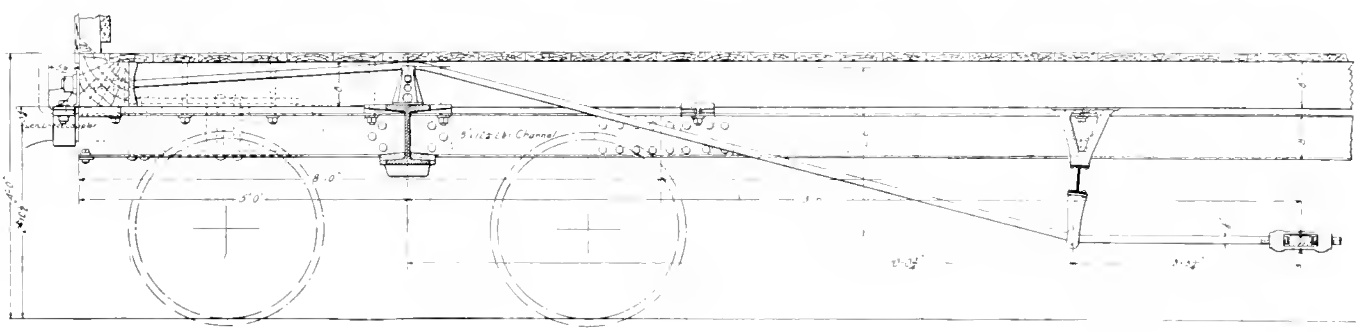
About two years ago the officials of the mechanical department of the New York Central Lines appointed a committee to prepare designs for a standard 36 ft., 80,000 lb. capacity, box car. When the designs were completed four cars were partially constructed at each of four points on the system in order to show clearly the different details of construction These were then carefully examined and criticized by the various officials and the design was perfected. The system has recently ordered 6,000 of these cars, the general dimensions of which are as follows:

Length over end sills	37 ft.
Length over couplers	40 ft. 2 ins.
Length inside of lining	36 ft. ½ in.
Width over sills	9 ft. 2 ins.
Width over eaves	9 ft. 7⅝ ins.
Width inside of girth	8 ft. 6 ins.
Width between lining	8 ft. 6⅜ ins.
Width, extreme, over door handles	10 ft.
Width of door openings	6 ft.
Height of door opening	7 ft. 6¾ ins.
Height, top of rail to eaves	12 ft. 6⅛ ins.
Height, top of rail to top of brake mast	14 ft.
Height, top of rail to top of running board	13 ft. 2½ ins.
Height, top of rail to centre of draw bar	2 ft. 10½ ins.
Height, top of floor to bottom of carline	8 ft. 2 ins.
Truck wheel base	5 ft. 6 ins.
Total wheel base	32 ft. 6 ins.
Approximate light weight	39,000 lbs.

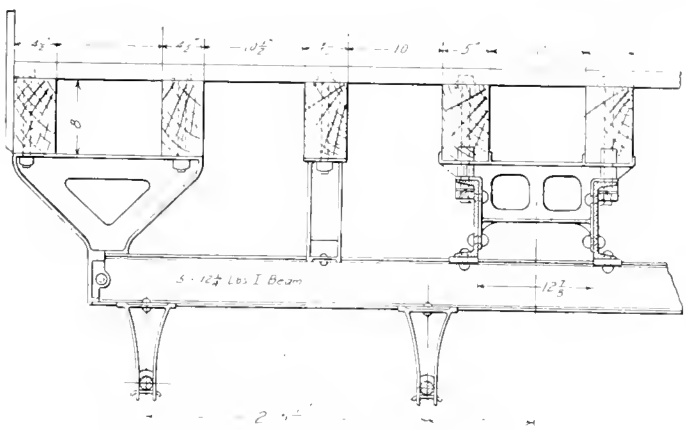
The underframe consists of two 5 x 8 in. centre sills, four 4½ x 8 in. intermediate sills and two 4½ x 8 in. side sills. These longitudinal sills are not mortised to the end sills, as is the usual practice, but their ends fit into malleable iron pocket castings, which are fastened to the end sills by lag screws, except in the case of the side sill pockets, which are secured by the same two bolts as the push pole casting. A combination pocket casting is used for the two centre



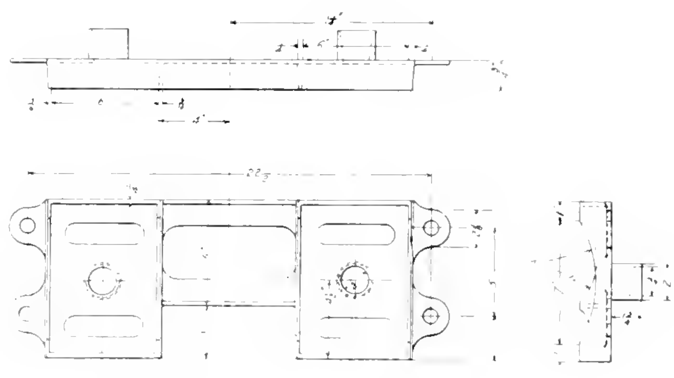
SECTIONS AND END VIEW OF STANDARD BOX CAR—NEW YORK CENTRAL LINES.



DRAFT BEAMS AND TRUSSING.



CROSS-SECTION AT NEEDLE BEAM.

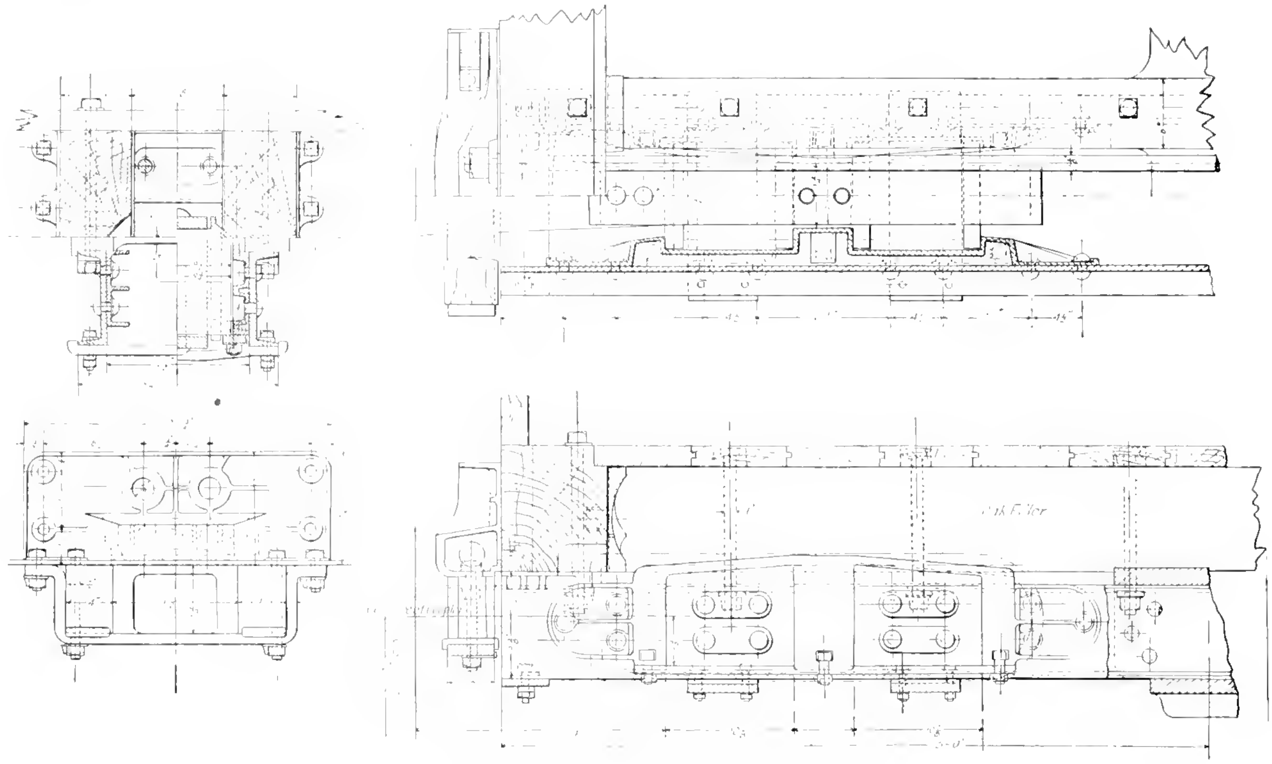


POCKET CASTING FOR CENTER SILLS.

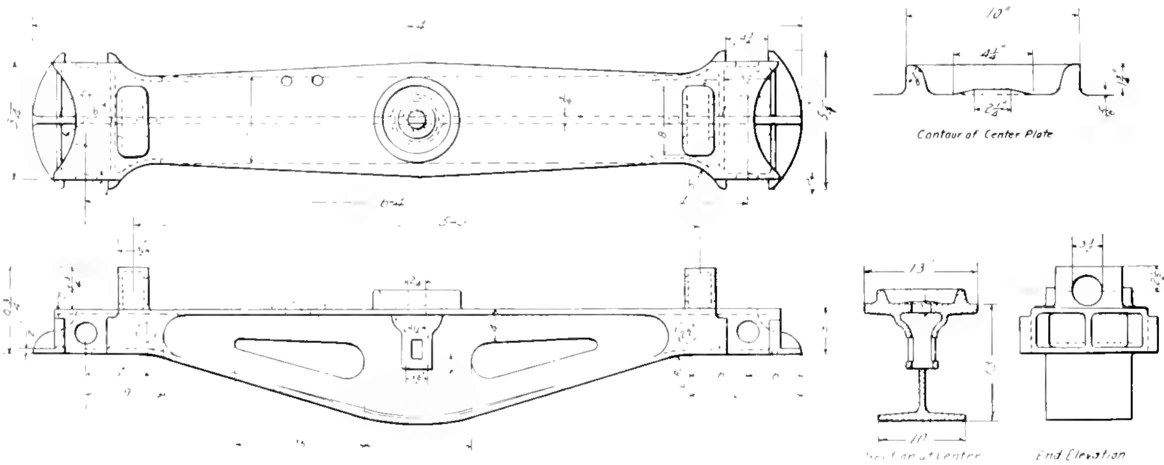
sills having lugs on it which fit into the end sill. Details of this casting, as well as of the one used for the intermediate sills, are illustrated.

The end sill is 9 ins. wide by $9\frac{3}{4}$ ins. deep. The underframing is tied together by four $1\frac{3}{8}$ in. truss rods, and to a certain extent by the steel draft sills. This construction is simple and facilitates the repairing of both the end and the longitudinal sills, and the strength of the end is not impaired by being mortised.

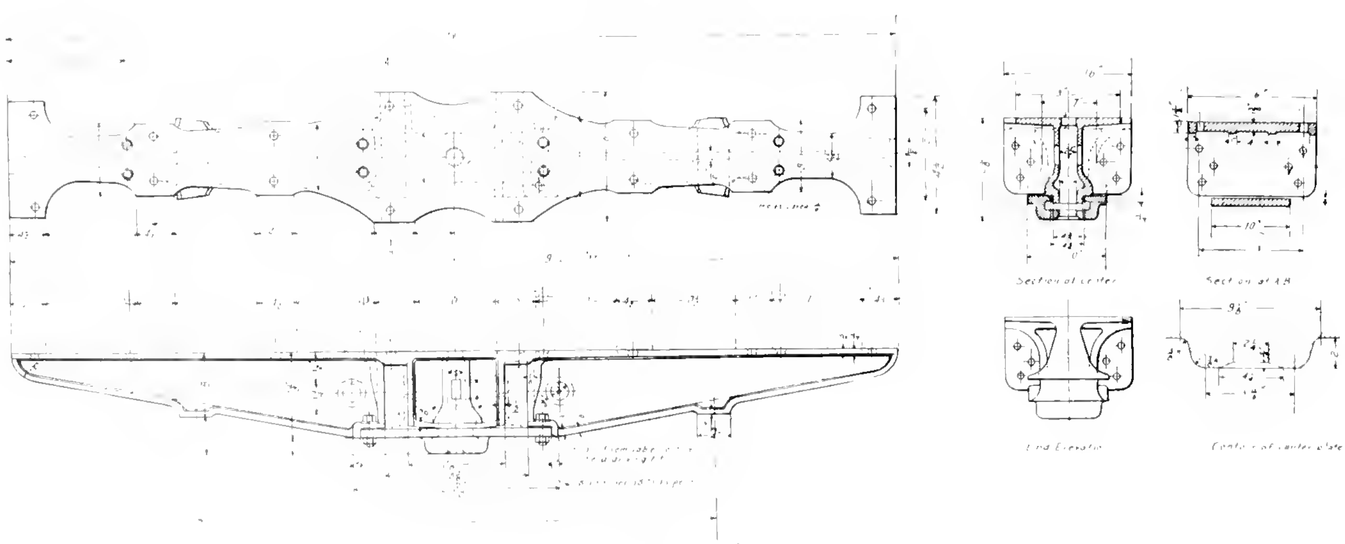
The draft sills extend the entire length of the car and consist of 8 in. channels, $21\frac{1}{4}$ lbs. per foot, each 8 ft. 10 ins. long, extending 3 ft. 10 ins. beyond the body bolster, where they are spliced to 8 in. channels, $18\frac{3}{4}$ lbs. per foot. The top of the draft sill, between the end sill and body bolster, is $1\frac{1}{8}$ ins. below the bottom of the centre sill. A filler casting is placed between the draft sills and the end sill, and the space between this and the body bolster is filled by an oak piece, $1\frac{1}{8}$ x 4 x $44\frac{1}{4}$ ins. Each draft sill is bolted to the end sill and to the centre sills by five 1-in. bolts, as shown on the illustration of the draft gear arrangement, and is



DRAFT GEAR ARRANGEMENT.



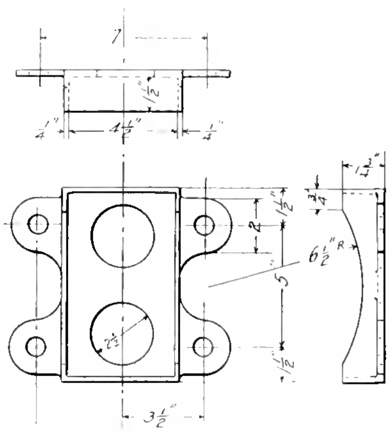
TRUCK BOLSTER.



BODY BOLSTER.

also riveted to the body bolster. These sills are very greatly stiffened by the malleable iron draft castings, which are arranged to take Miner tandem spring draft gear. The dead block is of malleable iron.

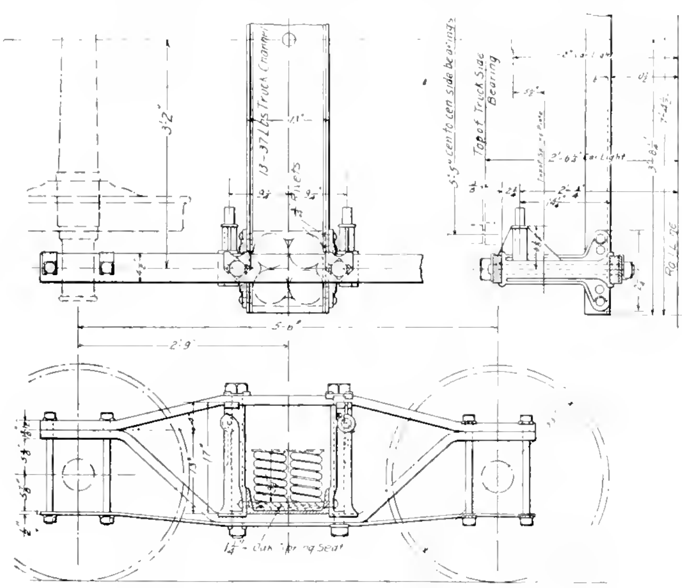
At a point near where the draft sill is spliced, about halfway between the body bolster and the needle beam, a filler-casting, placed between the draft sills, is riveted to them and is bolted to the centre sills. A somewhat similar casting is



POCKET FOR INTERMEDIATE SILLS.

used at each of the needle beams. The arrangement of the needle beams, which are 5 in., 12¼ lb., I beams, is rather unique and is shown clearly in one of the illustrations.

The draft sills will apparently have to transmit practically all of the pulling stresses, but in case of heavy buffing stresses the coupler horn will strike the buffing block and the more severe shocks will be transmitted through the end sills to the wooden sills, the draft sill, of course, carrying a part of the load. The body bolster is of steel, made by the Com-



TRUCK FOR BOX CAR.

monwealth Steel Company. As may be seen from the detail drawing, the centre plate is not cast on the bolster, and is not bolted in place until after the draft sills have been attached.

The side, corner and end posts and braces, of the sizes shown on the general drawing, fit into malleable iron pocket castings, which are either bolted or secured by lag screws to the side and end sills and plates. These posts and braces are secured to the upper pockets by carriage bolts. The framing is tied together by ⅞-in. rods, as shown. The car body is given a camber of one inch. The flooring is 1¾ ins. thick. The side sheathing and the inside lining are each 13/16 in. thick. The carlines are of pressed steel, made by the Cleveland Car Specialty Company, and are spaced at intervals of 4 ft 7 ins. A Chicago-Cleveland improved Winslow inside metal roof is used. The side doors are equipped with the National Malleable Casting Company's latch and hasp, and with the Camel Company's security door hangers. Columbia lock nuts are used throughout the car except for the column and journal box bolts in the truck.

The truck, as originally designed and as shown in the drawing, is of the diamond arch bar type with M. C. B. standard arch bars. However, on the cars now being built, solid cast steel truck side frames are being used in place of the arch bars. The steel pins which support the brake hangers are keyed in sockets cast on the column castings. The spring plank is a 13 in., 37 lb. truck channel, and the spring seat is an oak block 1¼ ins. thick. The bolster is of cast steel, with the centre plate and side bearings cast on it, made by the Commonwealth Steel Company. Simplex brake beams and Lappin chilled end steel brake shoes are used.

We are indebted for drawings and information to Mr. J. F. Deems, general superintendent of motive power.

ADVANTAGES OF REINFORCED CONCRETE.—When it is remembered that for heavy construction, where large pieces of timber form the principal means of support, the quality of material has, of late years, steadily depreciated and at the same time become more scarce, designers of industrial plants were perforce obliged to look about for some substitute that would permit of the construction of this class of buildings without materially adding to the cost and at the same time be better than the old method of construction. These conditions we find happily met in reinforced concrete, and the test of years has proven that for all types of building, and especially for the factory and warehouse class, this method of construction far outweighs, in all points, the older and less durable type of slow burning and wood constructed floors. Not only for floors and columns is reinforced concrete adaptable, but for walls as well, permitting much less material in the wall, while it gives added space for windows. This increases the brilliancy of the building, which is a most important feature in industrial plants. The chief points in favor of reinforced concrete are:

First: Reinforced concrete becomes stronger with age; slow burning becomes weaker, owing to the rotting of timbers, etc.

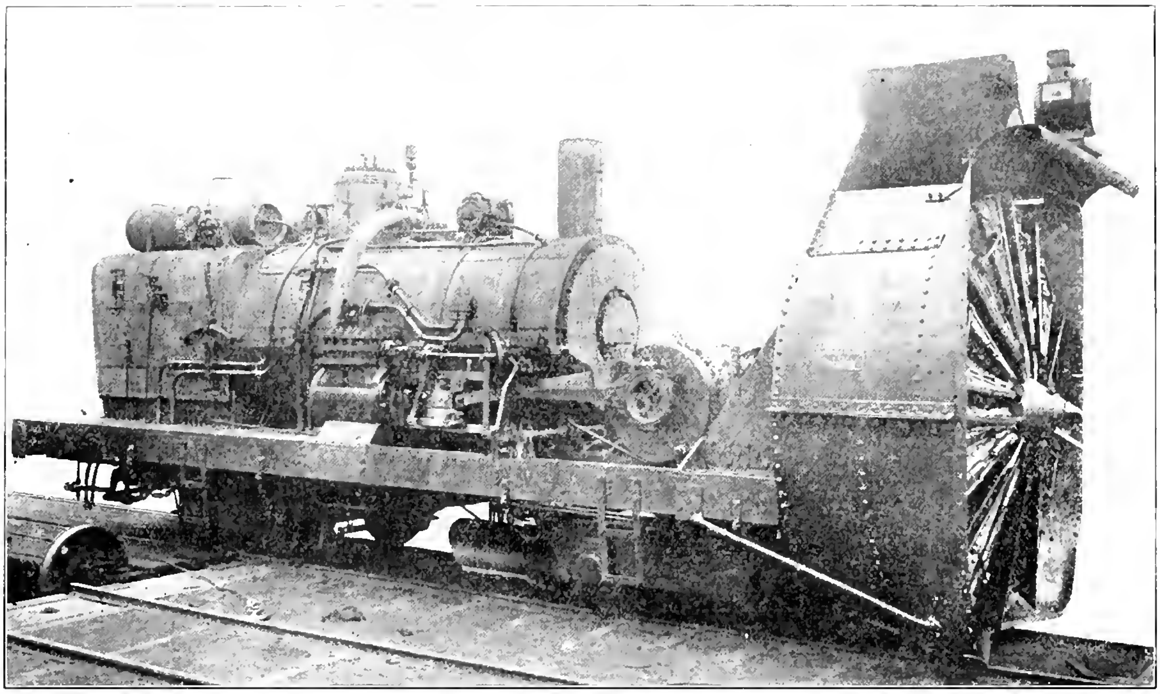
Second: Resistance to vibration, increasing the life of and lessening repairs to machinery.

Third: Low cost of insurance, and almost entire immunity from fire, thus avoiding loss of business due to shut-down of plant.

Fourth: Cheap materials and labor. Materials are found in practicality every locality.—*Mr. Emile G. Perrot in Cement Age.*

WHAT THE MECHANICAL DEPARTMENT REQUIRES OF THE STORE DEPARTMENT.—What is most needed by the mechanical man is promptness in furnishing him what he wants, when he wants it and where he wants it. This applies to cost figures as much as to castings. At Topeka the cost of repairs to each engine is carefully estimated in advance. We desire to bring immediately to gang foremen discrepancies, if any, between estimated cost and actual costs. This information is valueless to us and to them if only forthcoming at the end of a month or two months. We can go into Mr. Rice's office the day after any engine has left the shop and ascertain the total amount of materials and what kind, where used and their value, and we can also as promptly ascertain the total cost of labor repairs to any engine going out.—*Mr. Harrington Emerson, before the Railway Storekeepers' Association.*

TONNAGE MOVED.—The entire tonnage of the United States carried by the railroads one mile has nearly doubled in seven years. In 1897 it was 95,000,000,000 tons; in 1904 it was over 170,000,000,000; seven years more at the same rate of increase would mean 300,000,000,000 tons.



ROTARY SNOW PLOW WITH CAB REMOVED.

LARGEST ROTARY SNOW PLOW.

Denver, Northwestern & Pacific Railway.

The American Locomotive Company has recently completed at its Cooke works the largest rotary snow plow ever built, which has been delivered to the Denver, Northwestern & Pacific Railway. This plow will make a clear cut 13 ft. 4 ins. wide, and can be operated successfully through snow which has been packed and frozen until it is practically solid ice.

The general arrangement of its mechanism and also the result of its work through a very deep drift, which, as can be seen, reached fully to the roof of a passenger coach, is shown in the illustrations. The plow in general consists of a heavy steel frame mounted on two very heavy four-wheeled trucks with specially designed plate frames. The locomotive type boiler, with Belpaire firebox, is mounted near one end the frame, and furnishes steam for the two cylinders, shown on either side of the barrel, which are likewise supported on the frame. These cylinders have balanced slide valves, operated by Walschaert valve gear and drive bevel gear pinions which mesh with the bevel gear on the shaft of the cutting wheel. The construction necessitates the cylinders on either side operating in opposite directions, and the valve gear is properly connected for that purpose. The throttle and reverse levers are of locomotive type, and together with other control apparatus are located the same as in a locomotive.

The wheel consists of ten cone-shaped scoops of heavy plate, which have longitudinal openings in front and are set with the forward faces vertical. These scoops are securely fastened to the heavy cast steel hub, and also to a large steel disc forming the back of the wheel, all of which is secured to a shaft, extending back through and supported by two large pillow blocks. A bevel gear meshing with the pinions above mentioned is keyed to this shaft between the bearings. The openings of the scoops are fitted with cast steel knives, one hinged on either side of the opening, which are so connected and arranged as to automatically adjust themselves for cutting in either direction. The wheel is encased in a drum which has reversible hood at the top capable of being turned to either side by an air cylinder, to suit the direction in which the wheel is being rotated. The plates forming the drum are flanged to give an approximate rectangular cutting edge, the lower edges being specially heavy and shaped so as clear the snow very close to the rail.

The front truck of the plow is provided with both ice cutters and flangers, the former being mounted in front of the truck by a swinging frame so that they can be raised when crossing frogs and switches. They consist of heavy steel knives, projecting down just inside the rail and clearing the space for the wheel flanges. The flangers are hung at the rear of the truck and connected to bearings on the axle. Both ice cutters and flangers are raised and lowered by suitable air cylinders, and when in working order make it impossible for the plow to be derailed by ice or snow. The ice cutters are so constructed that in case they strike an obstruction such as a frog, two bolts will be sheared, allowing the cutter to swing backward and do no other damage to the truck.

The plow, as shown in the illustration, is wholly encased in a steel cab with suitable door and window openings, there being a floor placed over the bevel gear mechanism, and a

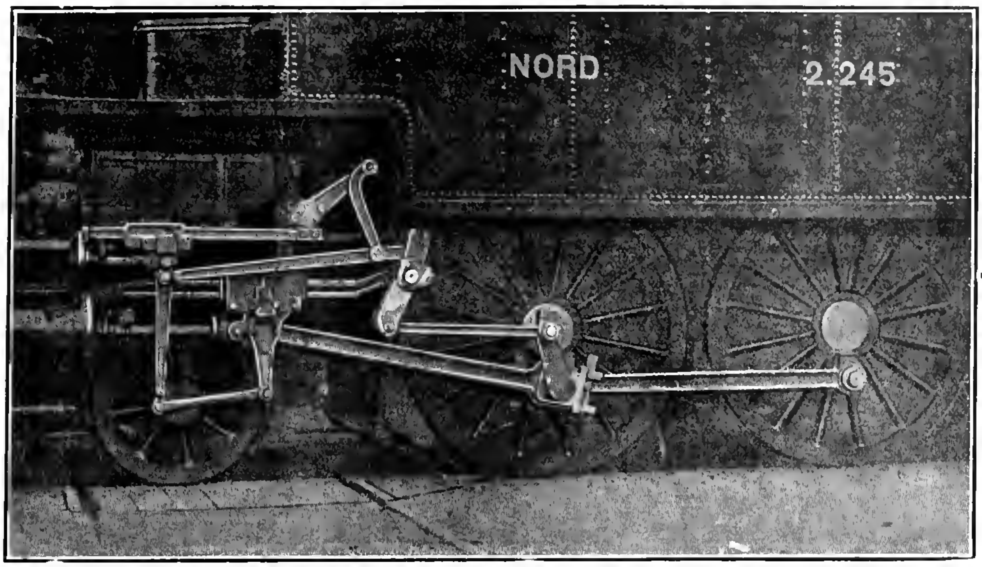
CUT MADE BY ROTARY SNOW PLOW.

cab arranged at that point for the pilot who controls the work by signalling the engineer of the plow and the pusher engine during the operation. The rear of the cab is suitably arranged for the engineer and fireman, there being a regular locomotive tender attached for coal and water supply. A turbine generator furnishes current for electric headlights and cab lights.

CAST STEEL CRANK AXLES, RODS AND VALVE GEAR.

NORTHERN RAILWAY OF FRANCE.

Nearly four years ago the Northern Railway of France started a series of experiments in the use of cast steel for locomotive parts which previously had been and usually are now made of forged steel or iron. At that time and subsequently the following parts made of cast steel have been applied to several different classes of locomotives: Main rods, side rods, crank axles, eccentric blades, guides, Walschaert valve gear parts, as well as driving boxes, piston heads, guide yokes, and other similar pieces. The results in service, covering various lengths of time up to four years and more, are reported as being uniformly favorable.

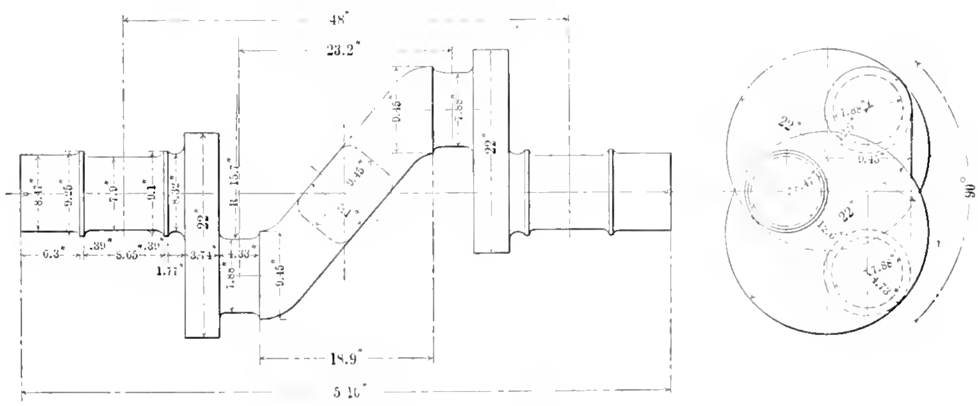


CAST STEEL RODS, GUIDES, VALVE GEAR, ETC., ON FRENCH LOCOMOTIVE.

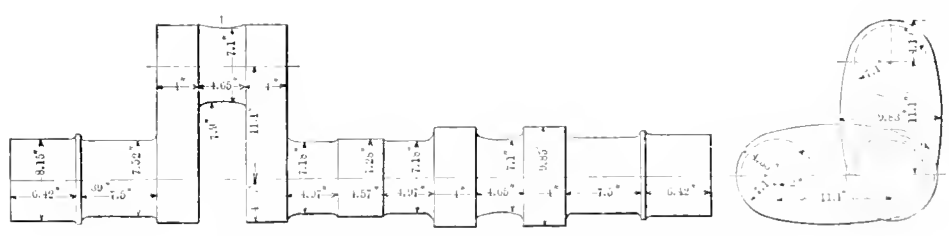
The points of greatest interest in these experiments lie in connection with the rods and cranked axles, and through the courtesy of M. Sartiaux, chief engineer of the railway, we are able to illustrate the construction of these parts.

While the locomotives on which these experiments have been conducted are comparatively small, still for similar service they are comparable with locomotives on American railways. The cranked axles have been applied in two different types; one a ten-wheel balanced compound locomotive having a tractive effort of 16,450 lbs. and an Atlantic type, also a balanced compound, having a tractive effort of 14,150 lbs. The former of these employed the crank axle with the oblique centre section and circular cheek plates, while the latter uses the design with elliptical cheek plates and straight centre section, both of which are shown in the illustrations. It will be noticed that the design of these axles closely follows the usual construction with forged steel, with the possible exception that the fillets are made of a larger radius. The main rod bearings in both cases are of the convex type, which is being used somewhat extensively abroad. The axles are, of course, cast in one piece and machined only where necessary for bearing surface or fits. We are informed that an axle of the oblique type has now made a mileage of over 88,000 miles in one case and over 37,000 on another locomotive, and an axle of the elliptic type has made a mileage of over 85,000 miles, and in all cases there is no evidence at present of any fault or imperfection of any kind.

The side and main rods were applied to a 4-4-4 type suburban tank locomotive with cylinders 17 ins. in diameter, stroke about 22 ins. and a 170 lbs. steam pressure, driving wheels being 66 ins. in diameter and carrying a weight on drivers of 71,000 lbs. This same locomotive, as can be seen in the reproduction from a photograph, also had all of the levers forming the Walschaert valve gear made of cast steel, as well as the guides, cross head, brake rigging, etc. The main rod follows the construction usually employed with forged steel and is nearly 4 ins. deep at the wrist pin and enlarging by means of an increase in the thickness of the flanges to 4¾ ins. near the crank pin. It has a uniform width of about 2⅜ ins., the web being nearly 13/16 in. thick. The rod measures from centre to centre about 5 ft. 4¼ ins. The side rod is of similar construction and has a



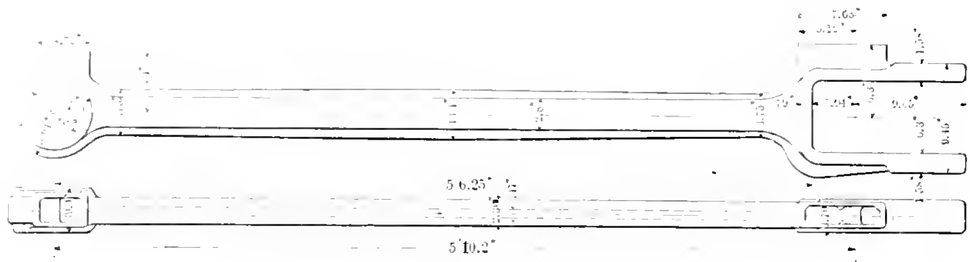
CAST STEEL CRANK AXLE—NOR. RY. OF FRANCE.



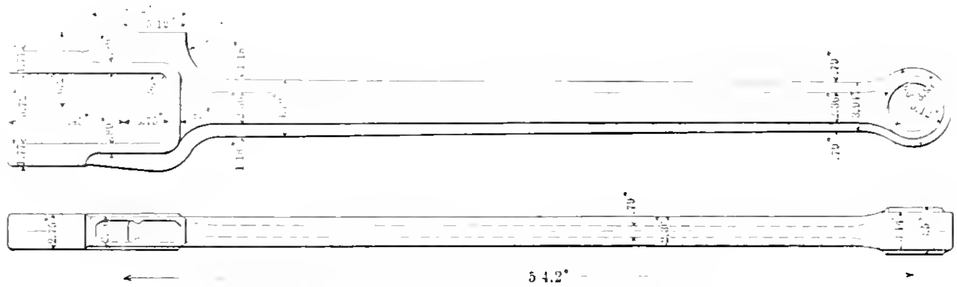
CAST STEEL CRANK AXLE—NOR. RY. OF FRANCE.

forked end with wedge and key on the main pin. It is made slightly deeper in the centre and slopes away to $3\frac{1}{4}$ ins. in depth at either end. This construction is clearly shown in both illustrations.

In speaking of this locomotive the "Revue Genérale des Chemins de Fer" states that since going into service this engine has made a mileage of about 56,000 miles up to May 12, 1906, at which time its machinery was in good condition and showed no trace of cracks. The right side rod after a service of about 18,000 miles showed a very small crack, less than an inch long, at the fillet, where the body of the rod joins the larger end. Repairs were made by welding in a small piece of wrought iron at this point and the rod was again put into service and has since shown no cause for comment, being perfectly sonnd.



CAST STEEL SIDE ROD—NOR. RY. OF FRANCE.

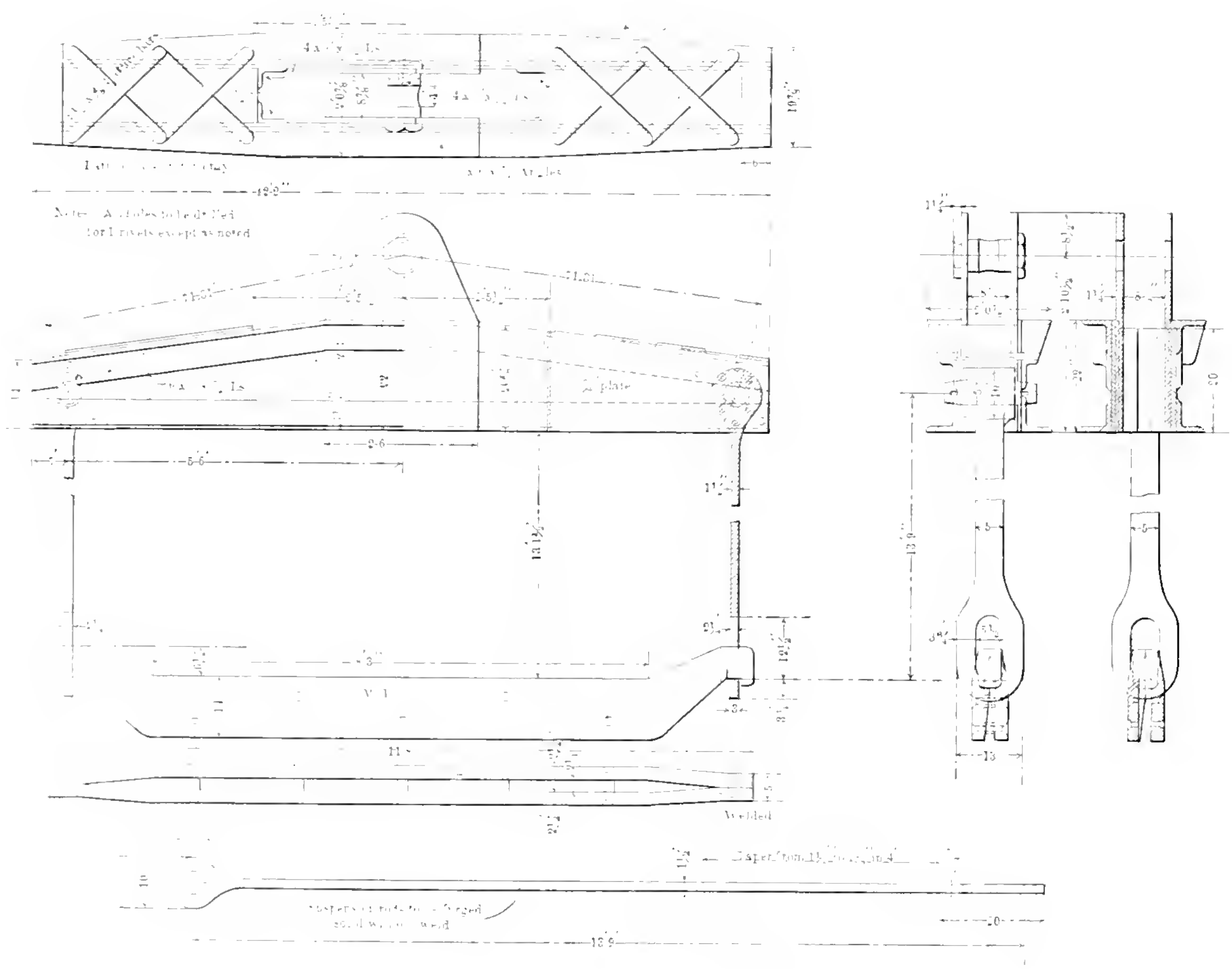


CAST STEEL MAIN ROD—NOR. RY. OF FRANCE.

We are unable at present to obtain the chemical and physical properties of the material used in these experiments, but from experience in other lines of work where similar material has been imported from France, as well as observations of French locomotives in this country, we would judge that the cast steel used is of a considerably higher grade than that ordinarily employed here. However, its use in connection with the valve gear at least would seem to be possible and might be advisable in some cases in this country.

LOCOMOTIVE CRANE LIFTING BEAM, SLING AND DOUBLE HOOK.

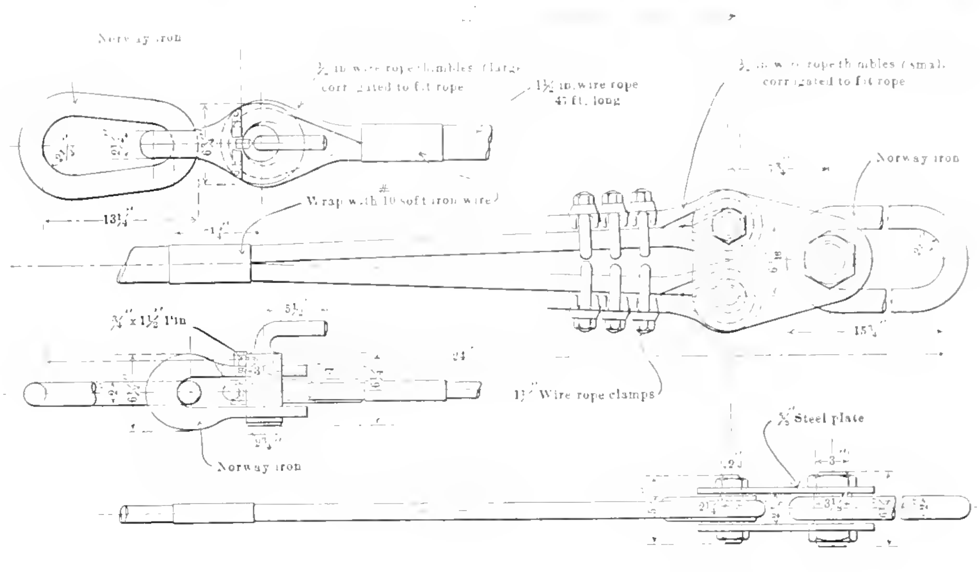
The accompanying engravings show the lifting beam for the rear end of a locomotive and the double hook and sling for the front end, as used with the 120-ton locomotive crane in the McKees Rocks shops of the Pittsburg & Lake Erie Railroad. The lower member of the lifting beam rests underneath the rear end of the frame, and the suspension rods and upper member or girder clear the sides and top of the



LOCOMOTIVE CRANE LIFTING BEAM.

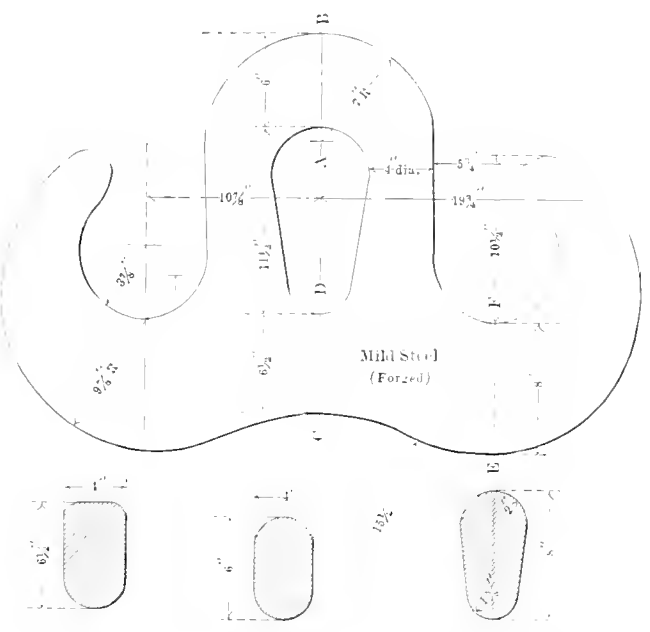
largest locomotive cab by several inches. The crane hook engages the 6¼-in. pin in the top girder. This lifting beam has a working capacity of 60 tons.

In lifting the front end the double hook is placed on the crane hook and the heavy cable sling, with links at each end which fit on the double hook, is passed under the front end close to the cylinder casting. The sling is made from a piece of 1½-in. steel wire rope 47 ft. long, which is passed through a thimble connecting with two links which form one end of the sling. The two strands of the rope are wrapped with No. 10 soft iron wire for several inches close to the thimble. The two ends of the rope are passed through thimbles and securely clamped with 1½-in. wire rope clamps, as shown. These two thimbles are connected by two 2¼-in. pins to the ⅜-in. steel plates, which are in turn connected by a 3⅛-in. pin to the large link.



DETAILS OF SLING FOR LIFTING FRONT END OF LOCOMOTIVE.

A framework has been erected at one end of the shop upon which the lifting beam, double hook and sling can be hung when they are not in use, so that the crane may be used for other purposes.



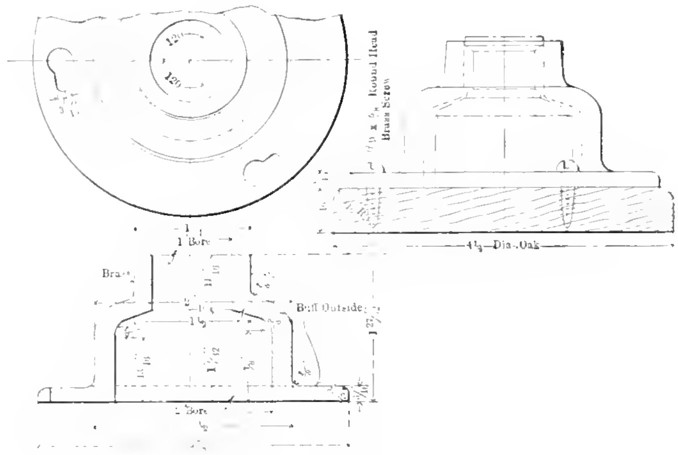
DOUBLE HOOK FOR LIFTING FRONT END OF LOCOMOTIVE.

The Railway Signal Association.—A stated meeting of The Railway Signal Association will be held at the Great Northern Hotel, Chicago, March 18. The subjects for discussion during the forenoon are, general specifications for electric interlocking and the installing and maintenance of storage batteries. During the afternoon the design of signal lamps and the report of a special committee on interlocking and block signals will be considered.

Superheaters.—The total number of locomotives equipped and in the course of construction having the Schmidt superheater was 1,664 on October 10. Fifty-one railroads are now using it, mostly in Continental Europe.—*Machinery.*

INK BOTTLE HOLDER.

The ink bottle holder illustrated herewith has been in use in the drawing room of the Illinois Central Railroad for several years and there is no record of one of them being upset, with the consequent spilling of ink. The thickness of the metal in the brass top is such as to insure stability and adapt



INK BOTTLE HOLDER.

the holder for a paper weight. The slotted holes in the flange of the metal case permit it to be revolved and removed whenever it becomes necessary to remove the ink bottle for cleaning. We are indebted to Mr. W. O. Moody, mechanical engineer, for drawings and information.

Co-operation.—Frequently problems or instructions are presented to the practical man for execution, in language or by formula which he does not understand, although he may know thoroughly well how the operation should be performed; a sense of wounded pride or humiliation prevents him asking for information, and sometimes a feeling of superiority prevents the theoretic man from either placing the problem in easier terms to be understood, or going in person and making such explanations as would be helpful to both. This together with many other similar circumstances all tend to prevent that bond of union or good fellowship between the practical and theoretic man, which should exist and which is essential to a high standard of ability or efficiency in men of either class.—*Mr. W. E. Symons at Purdue University.*

Take your time—but do not take the other fellow's.

(Established 1832).

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We are doing our best to make this journal of the greatest possible value to our readers and are always grateful for suggestions as to how we may better meet your needs. If we are not giving you what you need most, or are not doing things the way you think we ought to do them, let us know. Frank criticisms, as well as suggestions, are always welcome. We want every reader to feel that he has an interest in the paper and to co-operate with us in every way possible. We are able to visit personally only a comparatively small part of the field each year and must rely, to a large extent, upon you to keep us in touch with the important work you are doing.

The extract at the end of this editorial is taken from a specification for a lot of freight cars prepared by Mr. G. R. Henderson, consulting engineer. It is rather unusual, strange as it may seem, to state definitely the amount of the stresses which are to be provided for in designing freight cars. The ordinary specifications, where the car company is to design and build a car to meet the railroad company's requirements, deal quite largely with glittering generalities and a statement as to the specialties which are to be used on the car.

Any statement as to allowable fibre stresses is usually confined to those caused by the lading and the dead weight of the car. In spite of the fact that more or less is known as to the pulling and buffing stresses to which the car is ordinarily subjected it is not usually referred to in the specifications, and it is a question as to whether the average car designer has attempted to any great extent to analyze the effect of these stresses in combination with the vertical stresses due to the lading and to the dead weight of the car. From a discussion which took place at one of our railroad clubs it is even a question as to whether the average car designer knows how to intelligently analyze and determine the effect of the combination of these stresses. It is a fact that some of the most radical improvements which have been made in steel car design were suggested as the result of careful investigation into this subject along the same lines as pursued by the structural engineer. Undoubtedly the railroads would be benefited if a clause similar to that used by Mr. Henderson was incorporated in their car specifications and the finished designs were carefully checked over to see that they agreed with this part of the specification.

"The body is to be proportioned for carrying 125,000 lbs., uniformly distributed between the bolsters, in addition to the dead weight of the car. The center sills and draft attachments must be proportioned for a force of 100,000 lbs. pulling and 200,000 lbs. buffing, and strains due to either or both the horizontal forces and the vertical loading combined must not exceed 12,000 lbs. per sq. in. in tension (net sectional), or $12{,}000-(70\,l \div r)$ in compression, where $l =$ length and $r =$ the radius of gyration, both in inches."

"Nevertheless every railroad in the country goes on piling up figures which are meaningless and which are not and cannot be used for the only purpose for which they should be made, viz., to make it possible to determine with approximate exactitude the relation between the cost and the selling price."

"A great many of them were legitimate enough after they were inaugurated, but the necessity for them is past, and they are still kept up as a matter of form."

These two sentences are taken from some remarks which were made by Mr. J. W. Kendrick, second vice-president of the Santa Fe, in discussing a paper on "Railroading From a Business Point of View," recently presented before the New York Railroad Club. That a large proportion of the data which is worked up in the mechanical departments of some of our railroads is of very little use, and some of it entirely worthless, and that an equally large amount of data which should be had is not available, is a matter for serious comment. Consider, for instance, the important matter of engine performances. The superintendent of motive power has just received his monthly report, as you enter his office, and

certain figures are pointed out to you as being specially gratifying. As you look over the sheet you notice some figures that appear to be abnormal. You ask certain questions about them and a clerk is called in to tell just how they were obtained. He does the best he can to give you a good reason for the method by which they are derived, but finally it is admitted that some one at some time or other did it that way and the precedent has been followed ever since. As you examine the report further you find other things that do not look quite right, and after more questioning you are forced to the conclusion that as far as giving a true idea of the actual condition of affairs a considerable part of the report is not only worthless but misleading. Why does this condition exist? As nearly as you can find out it is not because the figures are being juggled to make a good showing, for in some cases the effect is just the opposite, but simply because it has always been done that way.

You inquire for certain data as to the cost of operation of a department and find that the records are in such shape that it is not available, even though it may be a matter of considerable importance. In some instances you find very complicated systems for keeping and compiling information which could just as well be obtained by an easier and simpler method. Such a condition is, indeed, deplorable, and it is hard to know how any motive power officer can expect to make a record under such conditions. It must, of course, be admitted that this condition does not exist on all railroads, but it is known to be true on a considerable number of them.

On the other hand, suppose the records are really reliable and give information showing clearly the actual conditions which exist. The motive power officer is a busy man and he can digest and keep in mind only a comparatively small amount of the important data concerning his department. Few men are capable of looking over a comparative statement containing many figures and readily grasping their import without a considerable amount of study. The officer's energy will be conserved and his efficiency greatly increased if such comparative figures are plotted graphically, so that a few minutes' study will enable him to gain an intelligent idea of the progress which is being made as compared with previous records. The superintendent of motive power or the division officer can have at a moment's command all of the important information concerning his road or division by having the important records plotted graphically in a small book, which can easily be carried in the side or breast pocket. If the records of his department are such that the figures are available it requires only a little work on the part of his chief clerk or one of the clerks to keep a book of this kind in good condition and up to date. It is gratifying to know that these graphical note books are being used quite generally, with splendid results, by the motive power officers on two or three large roads.

The subject of electrification of steam railroads has been a most attractive one for electrical engineers for several years past, and many papers have been written and presented before different societies, or in technical papers, bewailing the shortsightedness of steam railroad managers in not immediately changing their motive power. These have usually confined themselves to the handling of passenger traffic only, and, so far as we know, the paper of Messrs. Stillwell and Putnam, presented at the January meeting of the American Institute of Electrical Engineers, is the first attempt to prove the advisability of handling all kinds of traffic throughout the country by electric power. The paper takes the average percentage figures for each item of steam railroad maintenance and operation for five years as given in the reports of the Interstate Commerce Commission, and considering each item at some length, shows the decreased or increased cost probable with electric locomotives and cars operated on the single phase alternating current system. The final result derived is that such a change would save $250,000,000 a year in the cost of operation of our railroads. The method of treating the subject and the results obtained were apparently satisfactory to the Institute, at least there was no criticism heard at the meeting, but from a railroad standpoint they were sadly unconvincing for a number of reasons, not the least of which is the basing of the deductions on the figures given in the Interstate Commerce Commission reports, which are altogether too much condensed and general for any such purpose. For example, every railroad man knows that by no means all the coal charged to locomotives finds its way into the firebox or even on the tender. In some cases this same coal furnishes power to run shops, heat roundhouses and stations, dry sand, etc. Again the item "repairs and renewals of locomotives" includes many things in no way connected with locomotives. The same thing is true of many other items.

It apparently depends altogether on what you want to prove and your point of view as to what results you obtain from a comparison of the cost of steam and electric operation. For example, take it from a power standpoint. A horse power in the shape of a steam locomotive costs about $10.00 in round numbers. A modern power plant and permanent over-head structure costs about $100.00 a horse power in round numbers, and assuming that the total horse power of the plant will be equivalent to 40 per cent. of the horse power necessary in the shape of steam locomotives, this will make the power cost on the same basis at $40.00 for the electric permanent equipment. Electric locomotives will cost about another $10.00 a horse power, and in spite of the idea that there will be fewer locomotives required under those circumstances, any one familiar with the empty condition of roundhouses at periods of congestion will understand that fully as many electric locomotives as steam would be required to handle the traffic. This makes the first cost in the shape of a steam locomotive at $10.00 a horse power and $50.00 a horse power for electric, which at 5 per cent. capital charge and 5 per cent. depreciation and renewal charge makes a permanent cost of $1.00 per horse power year for steam and $5.00 for electric. As to operation, a horse power at the electric locomotive will cost about 6 mills an hour if the power plant load factor is maintained fairly high and constant. A horse power at the cylinders of a steam locomotive can be obtained ordinarily for about 4 lbs. of coal if the machine is properly handled, which, with coal at $2.00 a ton, would cost 4 mills; water will cost about 7 per cent. of the coal or three-tenths of a mill. It will further cost, at a maximum, 10 per cent. of the total coal bill to build and maintain coaling stations, which makes the horse power of a steam locomotive cost 4.7 mills per hour, but, of course, it takes coal to fire up locomotives, and they further burn coal while standing, and assuming that 25 per cent. of the total amount converted into horse power will cover this it gives practically 6 mills per horse power for operation, or the same as for the electric locomotive. It is, therefore, necessary to save, in some manner, $4.00 a horse power year on the basis of the combined horse power of the present steam locomotive equipment in order to arrive at the same cost of transportation. This appears quite different from the results obtained in the paper mentioned, but the assumptions and deductions made are at least fully as accurate.

There have been, and are being, several sections of steam railroad changed from steam to electric operation, and from the statements of the men responsible for such work, we would judge that their ideas on the subject are very clearly expressed by Mr. Aspinall when he stated before the International Railway Congress that his road (the Lancashire & Yorkshire) adopted electricity, "not to save money, but to make money." The inference from this, of course, is that the advantage of electricity for motive power is in the increased traffic attracted and the increased capacity of passenger terminals and tracks, and not at all in a decreased cost of operation for the present traffic. This we believe to be the true facts of the case, and that it is altogether idle and useless to attempt to prove the advisability of electrifying any and all the steam railroads in the country.

BETTERMENT WORK ON THE SANTA FE.

To The Editor:

In the elaborate article on "Betterment Work On The Santa Fe" in your December issue you explained at length, both by the use of graphical charts and actual figures, the exact saving to the company due to the introduction of betterment work and the bonus system. While a very considerable amount of space was devoted to a statement, in general terms, of the benefits gained by the workman due to the bonus system there was very little or practically no definite information as to just how much his wages had actually been increased. The following statement is made on page 452: "Thus far the betterment work on the Santa Fe has materially assisted in restoring harmony between the employer and employee and in greatly increasing the efficiency and reliability of the worker. His wages have been increased on an average from 10 to 20 per cent."

Those who are familiar with the question of wages in the western part of the country must realize that there has been a considerable advance in wages during the past few years, and that taking this into consideration the actual gain on the Santa Fe may really have been much less than indicated by the above statement. As a machinist I have been very much interested in your account of the bonus system, and while it would appear to afford many advantages to the workman I should like, if possible, to obtain some definite information as to the actual financial gain which a workman might expect in a shop where this system was to be introduced.

Sho-Me.

To The Editor:

Referring to Sho-Me's well raised question as to whether the general increase in wages throughout the West was not equal to the increase in pay of those earning bonus on the Santa Fe. The straight hourly rate of pay at the Topeka Shop is equal to that paid the same class of labor in this territory. In addition to this men earn extra money in the form of bonus.

Straight rate of pay has been advanced voluntarily by the Company with the general increase in wages throughout the West.. Following is a table showing rate of pay per hour with and without bonus since the year 1904. This is the actual record of eight men now in the shop. It is obviously best not to designate them by name:

		1904.		1905.		1906.		1907.	
Man No.	Occupation.	Rate per hour.	Rate per hour including bonus.	Rate per hour.	Rate per hour including bonus.	Rate per hour.	Rate per hour including bonus.	Rate per hour.	Per cent. 1906 monthly pay was to 1904 monthly pay.
1	Machinist	34	34	34	48	34	47.8	36	110
2	"	34	34	34	41.9	34	41.4	36	115
3	"	34	34	34	38.5	34	40.4	34	119
4	"	34	34	34	41.2	34	54.5	36	123
5	"	34	34	34	39.9	34	38.3	36	126.4
6	"	34	34	34	41.4	34	43.7	36	108.4
7	"	30	30	30	36.5	30	37.8	34	115
8	Helper	19	19	20	21.7	20	23.4	20	121.6

In 1904 the day was of 10 hours and there was a great deal of overtime. In 1906 the day was for several months 9 hours and there was virtually no overtime. The last column shows the increase in actual earnings in 1906 above 1904, the hourly rate not having changed, there being no overtime and the work day considerably shorter. In 1907 the hourly rate of pay was increased, but the hourly rate has nothing to do with bonus schedules or bonus earnings.

At some of the large shops and over the system as a whole the following is the December, 1906, record:

Shop.	No. of men working bonus.	Per cent. of increase of pay while working bonus.	Total bonus payments.
1	294	18	
2	482	13.4	
3	714	13.2	
4	800	22.3	
			$13,107.93
Other shops.	1169	12	$3,919.72

If the company has profited by lowering the cost of output, by not having to increase its shops and their equipment, by turning out work in shorter time, the workers have benefitted by

Not having to work overtime.
By working shorter hours.
By earning more money per hour.
By earning more money absolutely.

H. Emerson.

EQUALIZERS ON PASSENGER TRUCKS.

To The Editor:

Can you tell me whether there is any good reason why the equalizer is retained in American passenger trucks? It has seemed to me that the equalizer is very heavy and is a detriment rather than an advantage; that if the wheel-pieces are as stout as they should be to stand ordinary derailments, they might be given the duties of the equalizer without being made any heavier; and that the helical equalizer springs, placed so far from the end of the truck, give rise to those vibrations to the whole truck frame, which often make themselves so disagreeably perceptible in the car. On the other hand, the lightness, simplicity, and good riding qualities of the European truck are very attractive. I have sought by verbal inquiry and by book research for some time to find something in favor of the equalizer, but without success. While the details of construction have been more or less carefully studied, I have not found that designers have gone deeper into the general principles than to follow the customs of their predecessors. Can you enlighten me on this point? G. E.

THE FUTURE LOCOMOTIVE IN EUROPE.

It is interesting to note how the locomotives on both sides of the Atlantic, which, while starting from the same point, have widely diverged in matters of general design, as well as details, are now gradually becoming more and more nearly alike. This is due in some cases to the adoption in this country of features which have been long used on foreign railroads, notably the Walschaert valve gear and balanced compound, and much more to the increased traffic requirements on foreign roads making it necessary to design locomotives of a weight and power which were demanded in this country several years ago.

The following general conclusions as to the future European locomotive are taken from "La Locomotive Actuelle" (the modern locomotive), by Maurice Demoulin, mechanical engineer of the Western Railways of France, and show that the tendency points very clearly to a design which in its general features will be the same as is at present in general use for different classes of service in this country.

"The present tendencies, which are becoming more and more marked, and allow some fairly definite conclusions as to the future development of the locomotive to be drawn, may be summarized as follows:

1. Perhaps before long, general use of wide fireboxes, with a grate area of 37 to 48 square feet, with large heating surfaces, either of the Belpaire type, or with curved top, as much curved as possible or combined with the wagon-top which appears to be an interesting and possibly indispensable addition, will be made.

2. Return to smooth tubes in the case of boilers with long barrels. Adoption of heating surfaces proportional to the grate area; say 3,229 square feet and upwards.

3. Gradual increase in the adhesive weight, either by increasing the wheel-loads, when possible, or by increasing the number of coupled wheels. Locomotives for fast trains will thus probably more and more generally have six-coupled wheels, unless it proves possible to design Atlantic types having an adhesive weight of at least 40 tonnes.

4. The preceding conditions will before long involve, in Europe, the adoption of Pacific or Prairie types for high speed trains; such types will make it possible to have six coupled wheels, of large diameter, and wide fireboxes.

The Atlantic type, if still made in the future, will necessarily include the wide firebox; the possibility of using this constitutes the principal advantage of this type of locomotive.

In the case of the freight service, the consolidation type would appear to meet, for a long time to come, the requirements of the service; but it is equally probable that the use of the wide firebox, or at least of an enlarged firebox, with the barrel raised a corresponding amount, will become more and more general.

5. It also is probably possible to forecast the general development of a four-cylinder engine with the same number of cranks, either on the same axle or on two separate coupled axles. These engines may be expected to be normally of the compound type in spite of the present tendency of some makers to have simple engines with four cylinders. The latter type will not become more general unless the use of superheated steam, becomes developed to the extent expected by those who favor it.

As regards compounds, a general increase in the ratio of the high pressure to the low pressure cylinders may be expected. As a consequence of this increase (2.8 to 3 volumes) the valve gears may be connected, or even only two valve gears may be used; this simplification would be bound to become more and more general.

To sum up: however powerful and perfect the present locomotive may be, it can as yet only be considered as at one of the stages in its evolution, the further development of which it is easy to foresee."

COST OF MAINTAINING LARGE LOCOMOTIVES.

The yearly figures on locomotive repair costs from four large single track systems operating west of Chicago, which have greatly increased the size of their power within the last few years, are given in the following table:

Year.	No. Engines Owned.	Average Tractive Power lbs.	Repair Cost per Engine Mile	Repair Cost per 1000 lbs. Tractive Power per Mile.
		A.		
1903	1309	22,526	9.97 cts.	.4426 cts.
1904	1433	25,578	13.42 cts.	.5247 cts.
1905	1454	26,217	14.87 cts.	.5710 cts.
1906	1633	27,684	11.08 cts.	.4002 cts.
		B.		
1903	586	20,268	6.01 cts.	.2965 cts.
1904	731	21,261	7.56 cts.	.3556 cts.
1905	770	22,452	7.37 cts.	.3282 cts.
1906	800	23,112	7.82 cts.	.3383 cts.
		C.		
1903	929	19,832	7.68 cts.	.3879 cts.
1904	1191	21,470	9.64 cts.	.4301 cts.
1905	1234	22,095	10.65 cts.	.4816 cts.
1906	1257	23,430	6.86 cts.	.2932 cts.
		D.		
1903	1482	22,857	8.62 cts.	.3771 cts.
1904	1567	23,950	10.23 cts.	.4312 cts.
1905	1703	25,685	11.23 cts.	.4371 cts.
1906	1671	27,500	11.26 cts.	.4095 cts.

The different railway systems are simply indicated by letters, in order to avoid any invidious comparisons, though the comparison of the figures of one system with those of another would not be made or considered of any value by anyone familiar with the extreme variations between different systems in the matter of distributing accounts. The points desired to be brought out dwell within the figures of each system by itself.

For example, on system A, the addition of 324 very heavy locomotives (in addition to the equivalent supplanting of the usual percentage of light power destroyed or sold) within four years, has increased the average tractive effort per engine from 22,526 to 27,684 lbs., or 5,158 lbs. per engine—or, the locomotives at present in service average 22.9 per cent greater in tractive effort than in 1903. Shop labor troubles vitiate the repair cost figures for the years of 1904 and 1905, but with the system settled down again in 1906 the repair cost per engine mile of 11.08 cents may be taken as normal. But here we see that although this figure is 11.08 cents for 1906, as compared with the 9.97 cents for 1903, that really the repair cost of the tractive effort provided for producing transportation was less in 1906 than 1903, or .4002 cents as compared with .4426 cents per 1,000 lbs. of tractive effort per mile. In other words, the larger locomotives cost less to keep in repair than the previous lighter classes, though this result is due in some measure to a considerable modernization of shop facilities,

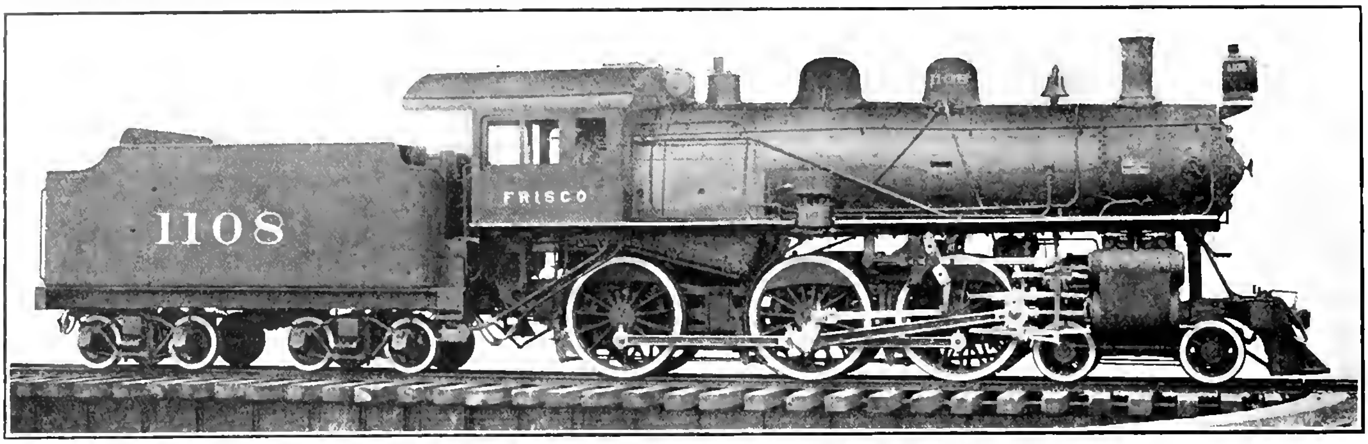
On system B, a lighter class of power is dealt with and the average tractive effort per locomotive has been increased but 13.4 per cent. Here we see that although a comparison of the year 1906 with 1903 apparently involves an apparent increase in repair costs chargeable to the increase in the size of the power, yet it will be noted that the immediate effect of the large increase in both size and number of the locomotives introduced in 1904 has been considerably reduced since—if we regard the preferred figures in the last column instead of cost per engine mile. The cause of the immediate jump upward in 1904 was lack of shop and roundhouse facilities for dealing with the new and heavy power.

On system C, an increase of 18.1 per cent. in the average amount of tractive effort per engine, while causing a similar first increase in repair costs, has eventually resulted in their reduction, to an even greater extent than is exhibited on system A. In this system also, the modernization of shop facilities has been a considerable element in the reduction of repair costs.

On system D, the weight of the power dealt with greatly resembles system A, and the amount of increase in the average amount of tractive effort is very similar, being 20.3 per cent. The shop facilities on this system have not been modernized to the extent found on systems A and C, but its repair cost exhibitions resemble the experience of all three of the others, in the introduction of heavier power at first raising the figures —with a final drop to a normal which is not an increase over that of the lighter power, if we consider the increases in the costs of material and labor during the last few years.

These exhibits would seem to imply that, if we estimate our repair costs on the fair basis of the amount of tractive power made available to the transportation department, the introduction of heavier locomotives on a railway system will cause repair costs to rise, until equivalent shop facilities have been provided. After which the repair costs will soon drop to, or even below, a level with the repair costs previously exhibited by the smaller power—which level, in view of the present increased costs of material and labor, implies that the larger locomotives are less expensive to maintain than the previous smaller ones.—*Railway and Engineering Review.*

The Economy of High Salaries.—In the first place, salaries and wages are too low. I am no advocate of increased pay rolls. But it is shown in practice that five men worth $4.00 a day each can do as much as ten $3.00 men, and the same is true of a foreman earning $80.00 or $90.00 compared to one earning $150.00 to $200.00; or of an official belonging to the $200.00 class compared to one belonging to the $600.00 class. The high priced man is not necessarily the best; but for the high price the best can be secured. It is manifestly false economy to pay a master mechanic $175.00 a month, and give him charge over one thousand or two thousand men with an aggregate pay roll of $60,000 to $100,000, when an intelligent $300.00 man, bringing perhaps in his train a $500.00 staff of assistants and specialists, can in six months lop off 15 to 30 per cent. of this pay roll, and at the same time by system and specialization and a method of reward according to merit, give increased and better service. Similarly, a $90.00 foreman is not an economical man to whom to entrust the requisitioning of thousands of dollars' worth of material each month; he will generally order perfunctorily and far beyond his needs, and it is not usual for his requisitions to be effectively checked up.—*Mr. H. W. Jacobs in The Engineering Magazine.*



TEN-WHEEL LOCOMOTIVE—ST. LOUIS & SAN FRANCISCO RAILROAD.

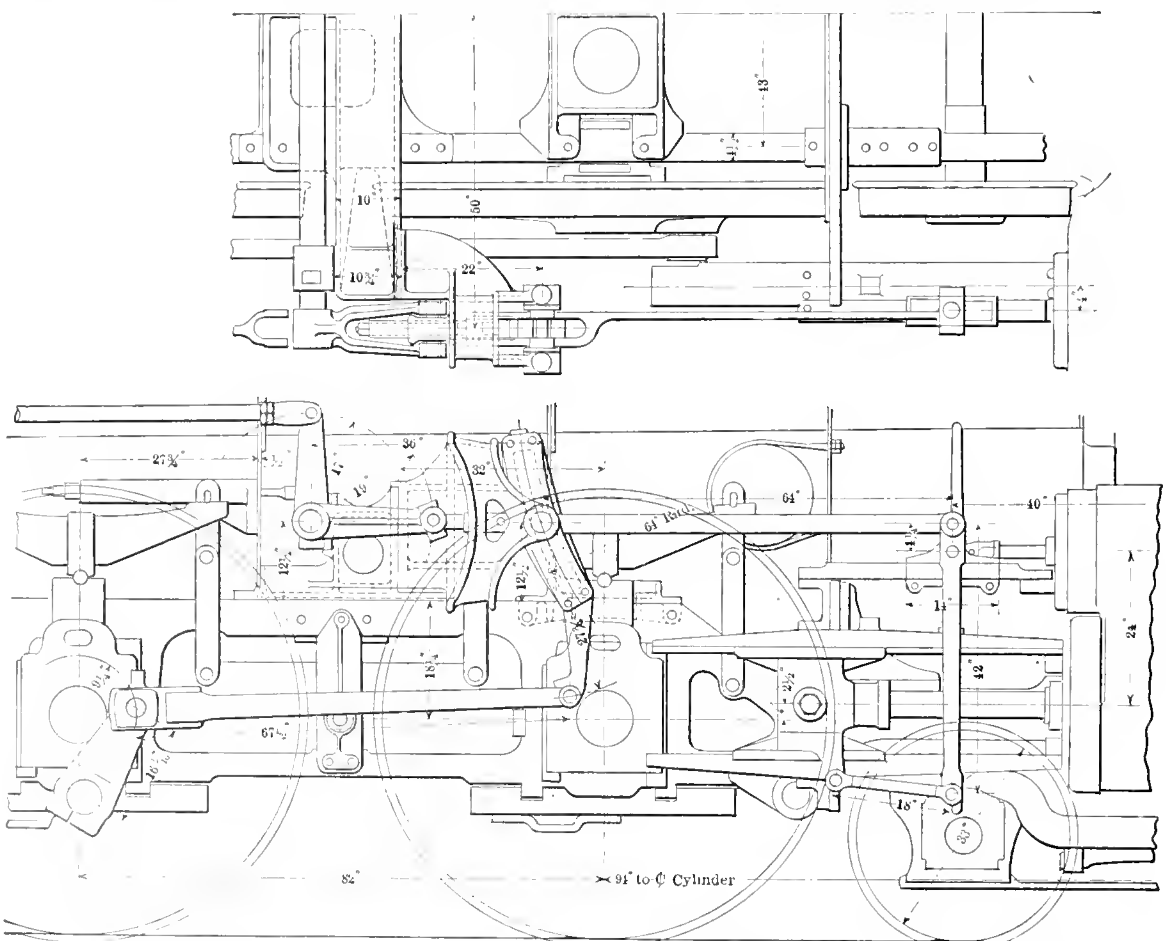
TEN WHEEL LOCOMOTIVE WITH WALSCHAERT VALVE GEAR.

St. Louis & San Francisco Railroad.

The American Locomotive Company has recently delivered from its Schenectady works an order of ten 10-wheel locomotives for the St. Louis and San Francisco Railroad to which an interesting application of the Walschaert valve gear has been made. This order follows a previous one of five engines of exactly the same dimensions which were equipped with the Stephenson valve gear. Since this last order has been delivered another small order to the same specifications has been made.

These locomotives are for heavy passenger and fast freight service on divisions where there are numerous grades from one to one and a half per cent., and the service to date is reported as being very satisfactory in every way. The general construction of the locomotive outside of the valve gear, while showing careful attention to details and to obtaining the best possible design of boiler for the type, offers nothing particularly unusual. The driving wheel base has been lengthened to 15 ft. 10 ins., which places the 69 in. wheels a considerable distance apart, allowing excellent opportunities for inspection.

The application of the Walschaert valve gear to a Pacific or 10-wheel locomotive presents difficulties not encountered on an Atlantic type, or any type having a two-wheeled engine truck. This is due to the location of the forward driving wheel, which is so far forward as to throw the guide yoke up to the centre of the guides, and not far enough forward to allow the yoke to be placed back of the first driver, and hence it is impossible to carry the link on a support from the guide yoke as is usually done. On the other hand, it is not advisable to locate the link at a point back of the front driving wheel, as this gives an excessively long radius bar and a short eccentric rod, hence the desirable location for the link places



WALSCHAERT VALVE GEAR—FRISCO LOCOMOTIVE.

it at a point somewhere near the centre of the front driving wheel.

The difficulty has been solved on this locomotive by the use of a cast steel cross tie on top of the frames, to which is secured a special shaped casting extending forward and outside of the driving wheel from which the link is supported. This cross casting also carries the bearing for the reverse shaft, the arm connection to the radius bar being made by a slip joint. The result by this arrangement is an almost ideal valve motion.

The construction of the valve gear is shown in the illustration herewith and the general dimensions, weights and ratios of the locomotive are as follows:

GENERAL DATA

Gauge	4 ft. 8½ in.
Service	Mixed
Fuel	Bituminous coal
Tractive effort	28,300 lbs.
Weight in working order	183,000 lbs.
Weight on drivers	136,000 lbs.
Weight on leading truck	47,000 lbs.
Weight of engine and tender in working order	310,800 lbs.
Wheel base, driving	15 ft. 10 in.
Wheel base, total	26 ft. 10 in.
Wheel base, engine and tender	55 ft. ¾ in.

RATIOS

Weight on drivers ÷ tractive effort	4.7
Total weight ÷ tractive effort	6.45
Tractive effort x diam. drivers ÷ heating surface	[illegible]
Total heating surface ÷ grate area	55.8
Firebox heating surface ÷ total heating surface, per cent	6.2
Weight on drivers ÷ total heating surface	51.1
Total weight ÷ total heating surface	69
Volume both cylinders	10.4 cu. ft.
Total heating surface ÷ vol. cylinders	255
Grate area ÷ vol. cylinders	4.58

CYLINDERS.

Kind	Simple
Diameter and stroke	21 x 26

VALVES.

Kind	Piston
Diameter	12 in.
Greatest travel	5¾ in.
Outside lap	1 1/16 in.
Inside clearance	0 in.
Lead, constant	¼ in.

WHEELS.

Driving, diameter over tires	69 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	9 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6 x 11 in.

BOILER.

Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	66⅜ in.
Firebox, length and width	102⅛ x 67¼ in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	F. 4½, S. and B. 4 in.
Tubes, number and outside diameter	318—2 in.
Tubes, length	15 ft. ½ in.
Heating surface, tubes	2,489.7 sq. ft.
Heating surface, firebox	164.6 sq. ft.
Heating surface, total	2,654.3 sq. ft.
Grate area	47.69 sq. ft.
Smokestack, diameter	15 and 17¾ in.
Smokestack height above rail	15 ft. 7 11/16 in.
Centre of boiler above rail	115 in.

TENDER.

Tank	Water bottom
Frame	10-in. chan.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	6,000 gals.
Coal capacity	10 tons

REINFORCED CONCRETE.—The observed facts impel the lay reader to one definite conclusion: That reinforced concrete is a dangerous building material, dangerous for unknown reasons, among which may be these: either (1) because safe methods of design have not yet been developed, or (2) because the commercially obtainable materials of construction are subject to unknown variations which may produce fatal weakness, or (3) because the quality of labor employed is not high enough to insure the safe construction of the design, even though design and materials be satisfactory. To this conclusion we are regretfully forced to subscribe. We make but one reservation—namely, that if an independent engineer be employed to either work out the design, or to prescribe specifications and verify the design by them; and if further an independent engineer be placed in charge of the construction work to see that it is properly done, then reinforced concrete construction is as safe as other types of construction. Under all other circumstances we believe it involves so much risk that it must be characterized as dangerous.—*Engineering News.*

WATER TUBE LOCOMOTIVE BOILER.

In October, 1905, pp. 376, we illustrated and briefly described the Roberts water tube locomotive boiler which had been put into service on the Paris-Lyons-Mediterranean Railway. The following account of a later design of the same arrangement and of the service of the first one is taken from Engineering (London):

The ordinary type of locomotives never gave complete satisfaction on the Algerian lines of the P. L. M. Ry. owing to the inferior quality of the feed-water; the firebox stays broke frequently, cracks developed in the firebox tube-plates, and matters became worse as engines of increased boiler pressure and higher power were put in service to cope with increased traffic; these had to be thoroughly overhauled after they had run only about 20,000 miles. The outside appearance of the Roberts boiler is the same as that of an ordinary locomotive boiler, but is of larger proportions.

The first boiler of this type was fitted to a freight locomotive which was transformed at the Algiers shops into a Bissell two-wheel truck engine. This engine was placed in service at the end of February, 1904, and up to February, 1906, it had run over 80,000 miles. At first, when the engine commenced dealing with the traffic, the evaporation of the boiler was highly satisfactory, but gradually decreased, owing to the deposit of scot and ashes round the tubes; this deposit had to be removed every time the locomotive entered the shed. To prevent this trouble, the boiler has been fitted with a tube-cleaning device, which consists of two thick tubes placed one above the other, parallel with the centre line of the boiler, and made with holes ⅛ in. in diameter, cut slanting. Steam jets through these holes clear away the deposit, the soot and dust escaping through the chimney under the action of the blower. By this means the high degree of evaporation is maintained, and the locomotive, it is claimed, is capable of hauling 25 per cent. more than those of ordinary type with equal grate area and heating surface.

Both the firebox and the drum-tubes of the first boiler were made of copper, with a view to minimize the danger of corrosion. But all the firebox tubes and the first row of drum-tubes began to show signs of failure, and had to be replaced by steel tubes, the former, after the locomotive had run a total of under 10,000 miles, and the latter, after about 22,000 miles. The steel tubes stand perfectly.

It had been hoped that the rapid circulation inside the tubes would prevent the formation of sediments, and such is the case at first; but sediment gradually forms in service, and is removed by cylindrical brush-cleaners for the tubes at the smokebox end, and by hammering for the furnace-tubes and the first sets of drum-tubes. Scrapers fitted to a flexible shaft driven by the power available at the locomotive shed, are also used for removing the scale from the tubes.

The boiler exhibited at Milan differs from the first one by slight modifications in the arrangement of the water return-tubes, and by the addition of doors to the sides of the tube sets for cleaning by hand, by a steam jet, or by brushes. The large return tubes which in the first boiler connected the feed-collecting tube at the bottom of the firebox to the two drums have been done away with, as it was found that the joints were difficult to maintain tight. They are replaced by large diameter steel tubes in the front and rear of the firebox, and covered by a fire-brick lining. The feed-collecting tube at the bottom of the firebox is made of circular bent plates riveted together; this has allowed the fitting of return tubes of large section. The steam and exhaust pipes are arranged in the usual way in the smokebox, access through the latter not being now needed for cleaning the tubes. The steam dome is near the smokebox end, and the manhole is provided in the rear end of the steam drum, the manhole cover being above the foot-plate, and independent of the safety-valves; an arrangement which facilitates the inspection of the steam drum.

The Canadian laws make an engineer or conductor who is intoxicated while on duty liable to imprisonment for ten years.

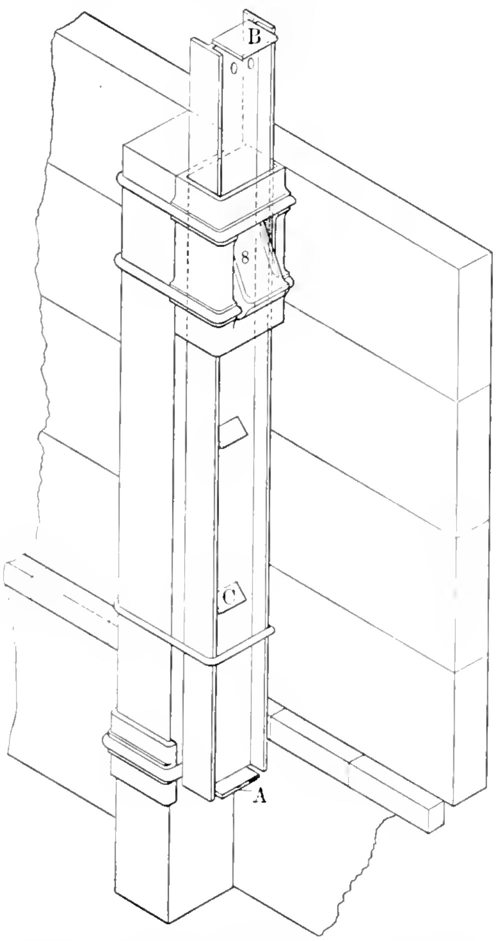
EXTENSION STAKES FOR GONDOLA AND FLAT CARS.

The expense of the temporary stakes, braces and ties for loading lumber or similar material on flat or gondola cars, in accordance with the M. C. B. rules for loading long material, amounts, on an average, to about $5.00 per car. These temporary fixtures are usually destroyed or lost in unloading the car. The lumbermen's associations in various parts of the country have protested against being called upon to furnish this temporary equipment and have suggested that the railroads arrange such of their cars as may be used for the transportation of this class of lading with permanent stakes.

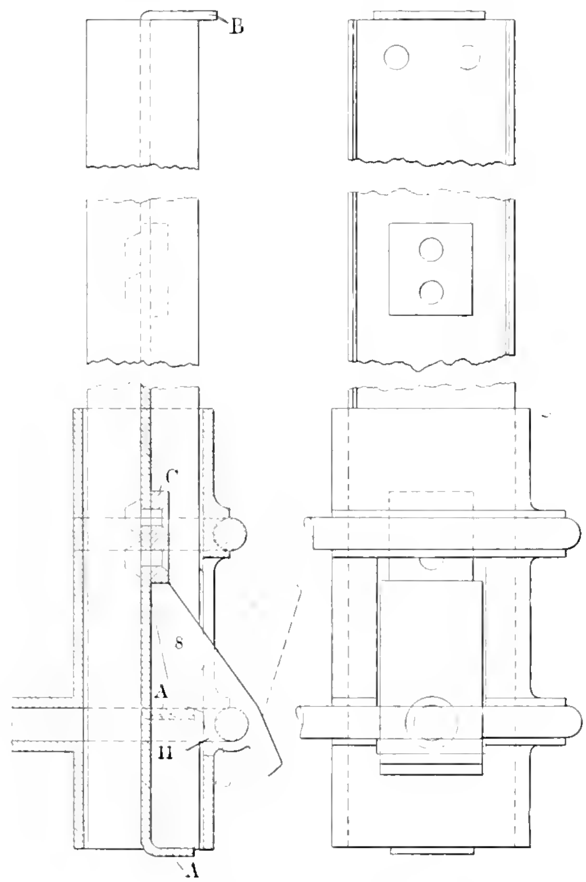
At a hearing before the Interstate Commerce Commission last September the general counsel for the lumbermen's associations stated that many of the cars on roads in the lumber district were temporarily equipped from 10 to 50 times a year and that very little of this temporary equipment was used a second time. It was estimated that over 300,000,000 feet of lumber were consumed annually in fitting the cars with these temporary stakes and braces. The aggregate cost of temporarily equipping flat and gondola cars in this service amounts to between eight and ten million dollars a year. Some individual shippers expend as much as $50,000 per year for this purpose. It was estimated that all of the flat cars in this country, something less than 150,000 in number, and an equal number of gondola cars, could be equipped with permanent stakes for less than the lumbermen pay each year for temporary stakes. It was also estimated that the annual revenue for transporting lumber and forest products in the United States amounted to $544,000,000, which is more than 20 per cent. of the annual gross earnings of the railroads.

The western railways and lumbermen have appointed committees to investigate the practicability of equipping the cars with permanent stakes, and the eastern roads have also undertaken a similar investigation. It is expected that the matter will be brought before the next Master Car Builders' convention and that some definite action will be taken in the near future.

Mr. W. O. Moody, mechanical engineer, and Mr. H. A. Simms, general car inspector, of the Illinois Central Railroad have recently patented a telescopic stake for use on cars hauling material of this kind which has several important advantages. The construction of the stake and its application to a gondola car are clearly shown on the accompanying illustrations. It must, of course, be understood that the lug C on the general drawing is of the same construction as the one shown in the detail drawing. The sectional view shows the position of the stake when it is extended. The pawl (8) engages with the lower edge of the block C, which is riveted to the web of the I beam stake. By throwing the pawl to the position shown by the dotted lines the stake may be lowered. The lip B at the top of the stake projects sufficiently so that it will engage with the stake pocket and not allow the stake to drop through to the ground. The projection or lip A at the bottom of the stake prevents it from being withdrawn at the top as the lip will engage with the lug (11) on the pawl. To withdraw the stake it is necessary to remove the pawl, which can only be done by removing the lower U bolt on which it fulcrums. The construction of the pawl is such that the stake can easily be raised to its extended position. The two holes at the top of the stake are for the purpose of tying across the car by means of a wire or chain. The construction and operation of this stake are very simple, and it has the advantage of being self-contained with no loose or removable parts.



APPLICATION OF EXTENSION STAKE TO GONDOLA CAR.



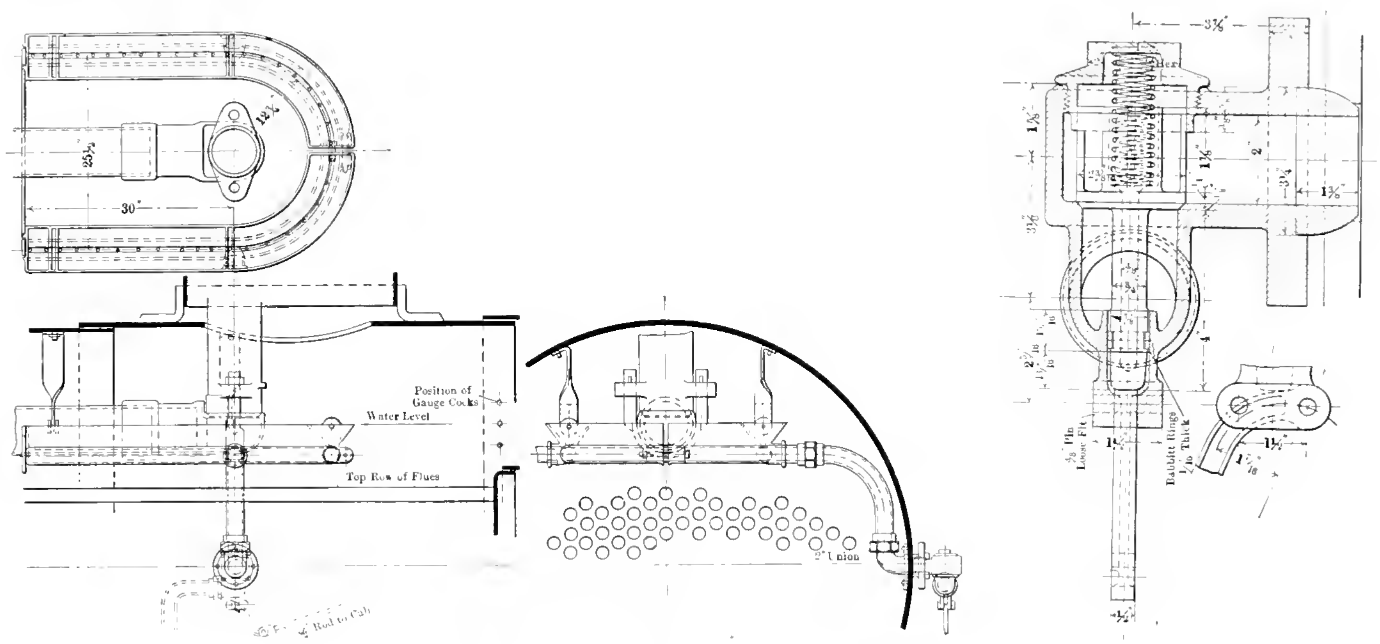
SIMMS-MOODY EXTENSION STAKE.

THE FUTURE LEADERS.—The great railroad man of to-morrow will be he who operates most economically, just as yesterday it was the traffic man who secured the most business, and to-day is the financial man who consolidates and juggles values. This signifies the ultimate ascendancy of the mechanical department, just as the tradesman has supplanted the feudal baron, and is in turn being superseded by the scientific methods of the engineer.—*Paul R. Brooks, before the New York Railroad Club.*

LOCOMOTIVE SKIMMER AND BLOW-OFF VALVE.

The undesirable, to say nothing of the disastrous results of a locomotive carrying a large amount of water over into the cylinders are too well recognized to need elaboration. There are many districts throughout the country where the boiler waters in use contain impurities of a nature to cause foaming, but because of the small amount of hard scale-forming impurities, and the recurrence of the difficulty only at certain periods of the year, making it undesirable to treat the water in a purifying plant or otherwise, dependence is placed altogether upon frequent blowing down of the boiler and numerous washouts to overcome the trouble.

It is specially for such conditions that the skimmer and its connections, which are illustrated herewith, have been designed by Mr. J. B. Barnes, superintendent of the locomotive and car departments of the Wabash Railroad and successfully applied and used by him for several years. Mr. Barnes informs us that a 21 x 26 in. Atlantic type locomotive, which before being fitted with this device required a washout at the end of every 1,000 mile run, was easily able after the application of the skimmer to make a mileage of over 8,000 miles between washouts, resulting not only in a saving due to the cost of washing out and the water lost, but also to a much greater saving in connection with keeping the locomotive in service, this saving being estimated at 50 hours saved between every washout when equipped with the skimmer.



BARNES BOILER SKIMMER AND BLOW-OFF VALVE.

The construction and application of the device is clearly evident in the illustrations, and it will be seen that it consists of a short U-shaped trough which includes in the same casting a 2 in. pipe below the trough with 5-16 in. cored holes between. This trough is located just above the average water level around the throttle pipe and has a connection on either side through 2 in. wrought iron pipes to specially designed blow-off valves located outside of the boiler shell.

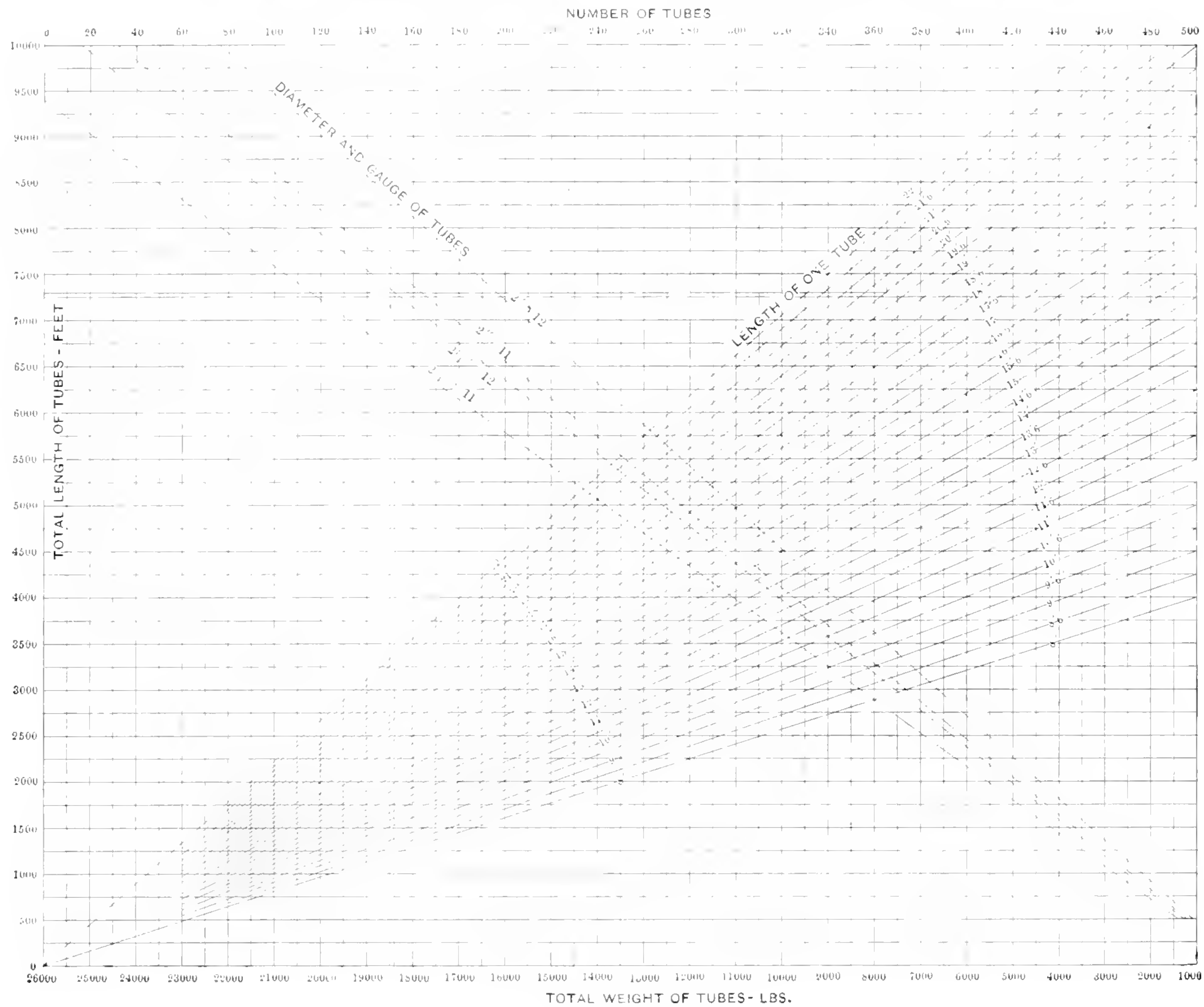
The blow-off valve, which is also illustrated, is made completely of brass with the exception of the spring, which is of German silver wire, and the lever, which is malleable iron or cast steel. The valve and its stem are cast intregal, the part above the seat having four wings, which fit into a projection of the nut, forming a guide for the upper part and the stem proper passing through the valve body, forming a lower guide, which insures the square and proper seating of the valve. It is operated by a lever from the cab and the spring insures positive seating when the lever is released.

Of course when the locomotive is working steam and starts to foam there is a rush of water upward around the throttle pipe, and on such occasions the opening of the blow-off valve forms a counter circulation which draws the water away from the throttle and prevents it being carried over into the cylinders. From experiments made up to this time it appears that at the same time the impurities causing the foaming, which naturally arise to the top of the water, are carried away by this skimmer, a fairly large part of the scale-forming impurities are also blown off, and the boilers so fitted do not appear to be as badly scaled as other boilers using the same water which are washed out eight times as often.

Both the skimmer and valve have been patented by Mr. J. B. Barnes.

SHOP LIGHTING.—A feature of incandescent electric lighting in shops and factories that has been greatly neglected is the provision for proper connections from the wire mains to the lamps used on the machines. The common practice has been to carry a double flexible cord from the nearest lamp socket to a portable lamp hung on some rickety fixture attached to the machine. That this practice is not only slovenly but actually dangerous besides has been shown frequently by the experience of unfortunate operators, who have been badly burned or shocked by short circuits. Not only this, but the use of lamp cord in such a manner is wasteful. It lies around on the floor, where the insulation is bruised and soon destroyed, and the amount of cord that may be needlessly used up in a large shop in the course of a year is a considerable item. Where the proper attention is given to this feature of machine shop equipment, the machines are wired the same as a building, the wires being carried up inside the columns of the machines in insulated cables. Sockets are provided at various convenient points, in which a plug, connected to a short length of flexible cord, can be inserted. The nearest socket will then be used to suit the convenience of the work. With machines wired in this manner, the length of flexible cord required is short.—*Iron Age.*

MANUFACTURING METHODS IN RAILROAD WORK.—In the large shops, however, where heavy rebuilding and new work is carried on together with finished material for shipment to outside points, and the work is not interrupted by roundhouse demands, manufacturing methods can and should prevail, and here the engineer is in his element, in fact, his knowledge is essential to its success.—*Mr. W. E. Symons at Purdue University.*



LENGTH AND WEIGHT OF BOILER TUBES.

LOCOMOTIVE BOILER TUBES.

HEATING SURFACE.—Table No. 1 affords a convenient means of quickly finding the total heating surface of the tubes in a boiler. The heating surface in square feet is given for tubes from 7 to 26 ft. in length and from $1\frac{1}{2}$ to $2\frac{1}{2}$ ins. in diameter, also the same information for each inch up to a foot in length and for fractions of an inch varying by sixteenths. In using the table, add together the heating surface for the feet, inches and fraction of an inch for one tube and multiply by the number of tubes. This table is similar to one arranged by Mr. Francis J. Cole, which appeared in our September, 1899, journal, page 292, except that additions have been made to cover the longer tubes which have come into use since that time.

FIRE AREA.—The total fire area of the tubes in a boiler may quickly be found by means of table No. 2. This shows the fire area for from 1 to 10 tubes of various gauges and from $1\frac{3}{4}$ to $2\frac{1}{2}$ ins. in diameter. As an example, to find the fire area of 548 2-in. tubes, No. 12 gauge: Under 2-in. tubes, No 12 gauge, find the area for 5 tubes and move the decimal point two places to the right (1245); add to this the area for four tubes with the decimal point moved one place to the right (99.6), and the area for eight tubes (19.9), which gives a total of 1,364.5 sq. ft.

LENGTH AND WEIGHT OF TUBES.—The accompanying chart affords a quick and convenient means of estimating the length and weight of the tubes in a boiler. The item of the weight of tubes becomes an important one in the design of locomotives where the weights have to be held strictly within given limits, and it is sometimes necessary to change the gauge in the thickness of the tubes to enable the designer to keep within the weight limit and still retain the desired total heating surface. Starting at the top of the diagram with the given number of tubes, follow the line vertically until it intersects the diagonal of the given length of the tubes (for calculating weights or aggregate lengths, this length should be taken as one inch more than the normal length to allow for beading), follow the horizontal line at this intersection until it intersects the diagonal of the given diameter and gauge and thence to the bottom of the chart, where the total weight may be read. To obtain the aggregate length of the flues, follow the horizontal from the intersection of the vertical for the number

FIRE AREA OF TUBES.

Diameter in inches.	$1\frac{3}{4}$			2			$2\frac{1}{4}$		
Gauge	13	12	11	13	12	11	13	12	11
Area 1 tube..	1.917	1.84	1.767	2.58	2.49	2.405	3.341	3.24	3.142
Area 2 tube..	3.834	3.68	3.534	5.16	4.98	4.810	6.682	6.48	6.283
Area 3 tube...	5.751	5.52	5.301	7.74	7.47	7.215	10.023	9.72	9.425
Area 4 tube.	7.668	7.36	7.068	10.32	9.96	9.620	13.364	12.96	12.566
Area 5 tube.	9.585	9.20	8.835	12.90	12.45	12.025	16.705	16.20	15.708
Area 6 tube..	11.502	11.04	10.602	15.48	14.94	14.430	20.046	19.44	18.849
Area 7 tube..	13.419	12.88	12.369	18.06	17.43	16.835	23.387	22.68	21.991
Area 8 tube..	15.336	14.72	13.136	20.64	19.92	19.240	26.728	25.92	25.133
Area 9 tube..........	17.253	16.56	15.903	23.22	22.41	21.645	30.069	29.16	28.274

HEATING SURFACE OF FLUES IN SQUARE FEET

Outside diameter of flues.	Circumference in inches.	FEET. 7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1½	4.7124	2.747	3.139	3.531	3.921	4.316	4.709	5.101	5.494	5.886	6.278	6.671	7.062	7.455	7.848	8.240	8.633	9.025	9.418	9.810	10.202
1¾	5.4978	3.207	3.665	4.124	4.582	5.040	5.498	5.956	6.415	6.873	7.331	7.789	8.247	8.706	9.164	9.622	10.080	10.538	10.997	11.455	11.913
2	6.2832	3.665	4.189	4.712	5.236	5.760	6.283	6.807	7.330	7.854	8.377	8.901	9.425	9.948	10.472	10.995	11.519	12.043	12.566	13.090	13.613
2¼	7.0686	4.121	4.710	5.298	5.887	6.476	7.064	7.653	8.242	8.830	9.419	10.008	10.596	11.185	11.771	12.363	12.951	13.540	14.129	14.717	15.306
2½	7.8540	4.581	5.236	5.890	6.545	7.199	7.854	8.508	9.163	9.817	10.472	11.126	11.781	12.435	13.090	13.744	14.399	15.053	15.708	16.362	17.017

Outside diameter of flues.	INCHES. 1	2	3	4	5	6	7	8	9	10	11	12	FRACTIONS OF AN INCH. 1-16	⅛	3-16	¼	5-16	⅜	7-16	½	9-16	⅝	11-16	¾	13-16	⅞	15-16
1½	.033	.065	.097	.131	.164	.196	.229	.260	.294	.327	.360	.392	.002	.004	.006	.008	.010	.012	.014	.016	.018	.020	.022	.024	.026	.028	.031
1¾	.038	.076	.114	.152	.191	.229	.267	.305	.342	.382	.418	.458	.002	.005	.007	.009	.012	.014	.017	.019	.021	.024	.026	.028	.031	.033	.036
2	.044	.087	.131	.174	.218	.262	.305	.349	.392	.436	.479	.528	.003	.005	.008	.011	.013	.016	.019	.022	.024	.027	.030	.033	.035	.038	.041
2¼	.049	.098	.147	.196	.245	.291	.343	.393	.442	.491	.539	.589	.003	.006	.009	.012	.015	.018	.021	.024	.028	.031	.031	.037	.040	.043	.046
2½	.054	.119	.163	.218	.272	.327	.381	.436	.490	.540	.599	.654	.003	.007	.010	.014	.017	.020	.024	.027	.031	.034	.037	.041	.044	.048	.051

of tubes and the diagonal for the length of the tubes to the left side of the diagram. Lines on the chart show the method of finding the length and weight of 365 tubes 20 ft. long, 2¼ ins., outside diameter. The total length is about 7,300 ft. and they weigh about 18,400 lbs. These weights are based on the nominal weights of the tubes plus 2½ per cent. to allow for overweight. This gives the following weights per foot: 2.22 lbs. for 2 in. No. 12; 2.44 lbs. for 2 in. No. 11; 2.52 for 2¼ in. No. 12; 2.77 lbs. for 2¼ in No. 11. This chart is similar to one presented by Mr. F. K. Caswell in our February, 1901, journal, page 64, except that it has been adapted for the longer tubes which have come into use since that time.

EXHIBITS AT THE ATLANTIC CITY CONVENTIONS.

The secretary of the Railway Supply Men has issued a circular to the members giving information concerning the plans for the exhibition to be held on the Steel Pier in connection with the Master Mechanic's and Master Car Builders' conventions, June 12-19, 1907. It is planned to depart from the usual custom at this exhibition by accepting an offer from the Atlantic City Hotel Men's Association to erect all booths and exhibit structures. This association has engaged the services of an architect and plans have been prepared for the purpose of obtaining booths which will be uniform in appearance and decoration, and make the best possible use of the space available on the Steel Pier. The circular is accompanied by a reproduction from a water color showing the appearance of the pier with the exhibit spaces as planned.

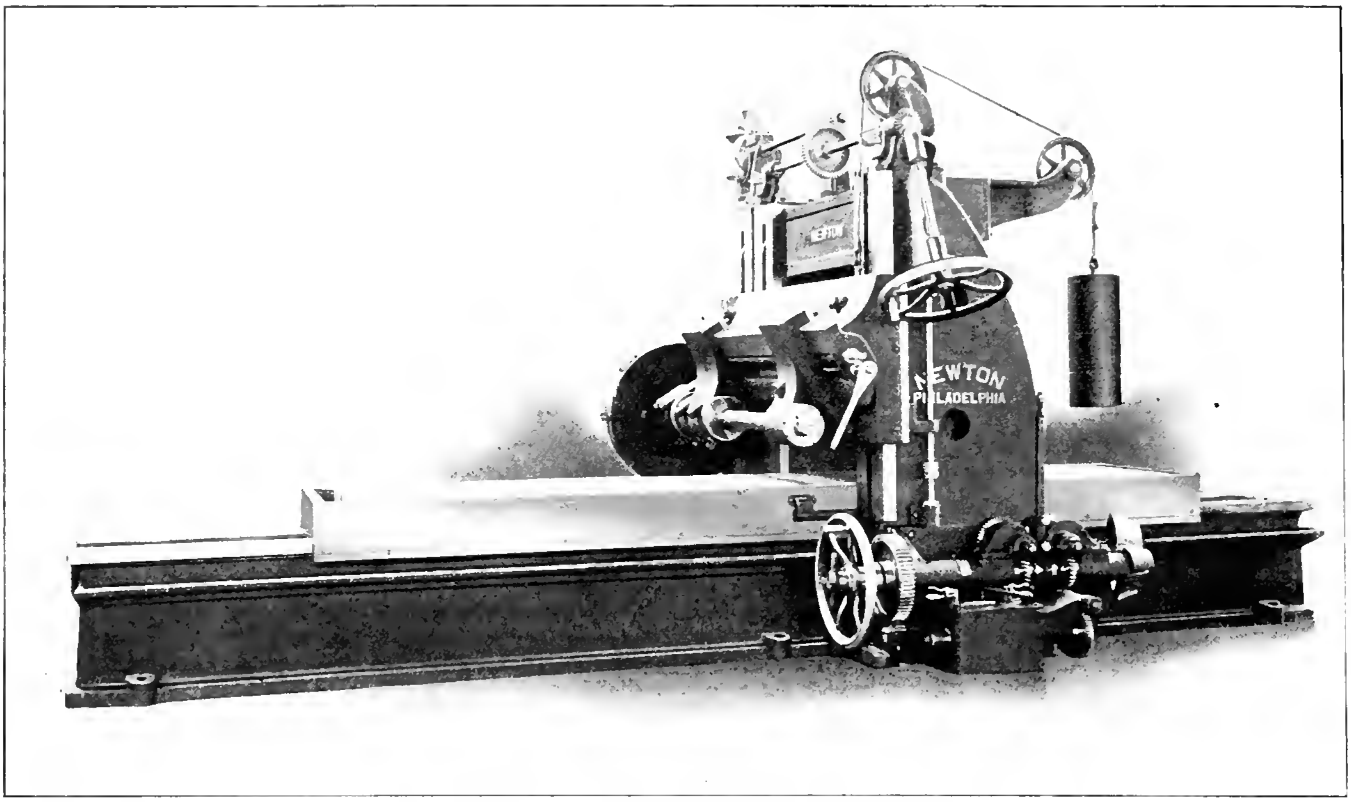
If the present plans are carried out the general appearance of the exhibition will be much improved over that of previous years and the expense to the exhibitors for better facilities than usual will be decreased. The booths will be the property of the Atlantic City Hotel Men's Association and will be available for use in succeeding years at a lower price than is to be charged for this year. The same association agrees to furnish all furniture, such as desks, tables, chairs, etc., at a standard price, which is given in the circular. The booths will be rented at a cost of 50 cents a sq. ft. and will be ready for use on June 1. It is specified that all exhibits must be completed by Tuesday evening, June 11th, and must be removed prior to June 26. It is arranged to furnish steam, at 100 lbs. pressure, free of charge, the exhibitor paying for his own connections. Electric current for both power and lighting will be available and compressed air will be provided in the customary way, the consumer making his own arrangements with the exhibitors who have compressors in operation.

It is requested that all those expecting to make exhibits will inform the secretary, Mr. Bruce V. Crandall, 510 Security Building, Chicago, Ill., as soon as possible. At the issuing of this circular application had been made for fully 35 per cent. of the available space but none had then been assigned.

REINFORCED CONCRETE.—Concerning the value of reinforced concrete for factory buildings, I would say that there is no question as to its manifest advantages in incombustibility, rigidity, and permanence. There are, however, some disadvantages in its use which must be taken into consideration in recommending this material. These are the treatment of outside walls to insure freedom from cracks and a pleasing appearance; the size of interior columns where there are a number of stories to be supported; and the increased weight upon the foundations where the ground is soft. It is probable that as time goes on, we shall learn more with regard to methods of overcoming the above mentioned disadvantages, but now there is plenty of chance for study along this line.—*Mr. J. R. Worcester in Cement Age.*

INVITE CRITICISM.—Reach far and grasp everything in sight and struggle for more; invite criticism and do not either shrink from or fail to defend the title of crank; but, first be absolutely sure you are right, that your position is based on sound engineering principles, both in theory and practice. Criticism that is known to be the forerunner of unqualified endorsements are blessings in disguise, and music to the ears of those they are directed against.—*Mr. W. E. Symons at Purdue University.*

ADDRESSES AT PURDUE UNIVERSITY.—On January 21 Mr. Wilson E. Symons, president of the Pioneer Cast Steel Truck Company, Chicago, addressed the engineering assembly of Purdue University on the subject of "Theory vs. Practice in the Work of the Mechanical Engineer." On January 28 the same assembly was addressed by Mr. Harrington Emerson, expert production engineer, who took as his subject "Railroad Operating Records."

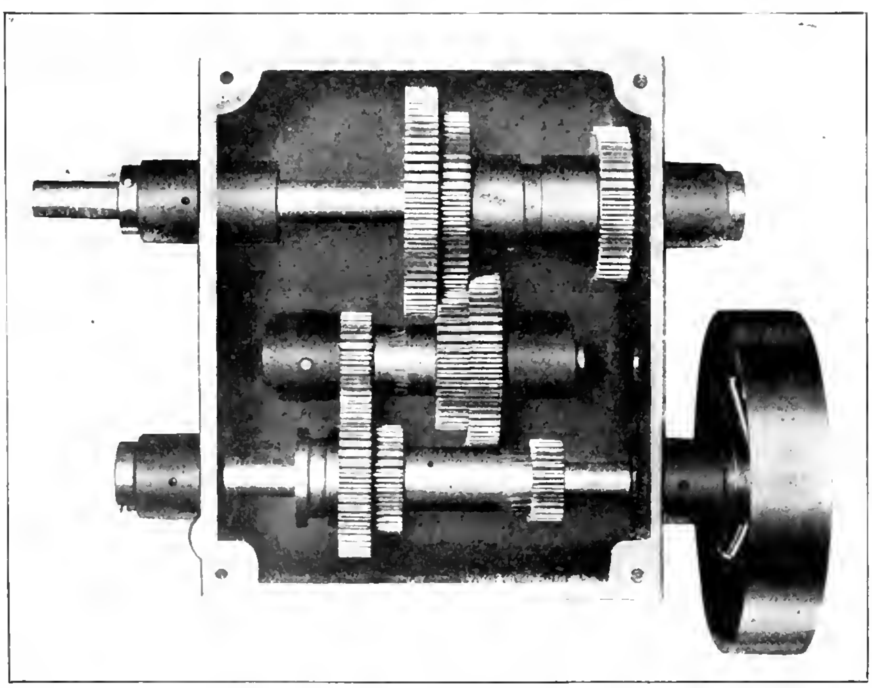


WORKING SIDE OF HEAVY NEWTON SLAB MILLING MACHINE.

HIGH DUTY SLAB MILLING MACHINE.

Improved shop methods on our railroads have made it necessary to practically redesign many of the machine tools during the past few years. The more recent designs of slab milling machines have met with considerable favor and the range of work handled by them has been greatly extended. The older type machines were, as a rule, hardly stiff enough to use the ordinary steel cutters to advantage, but with the stronger and stiffer machines, used in connection with high speed steel cutters, it has been found economical in many instances to do work formerly done only on planers, and in some cases a considerable saving has been made by removing surplus metal by these machines rather than by forging closer to the finished sizes.

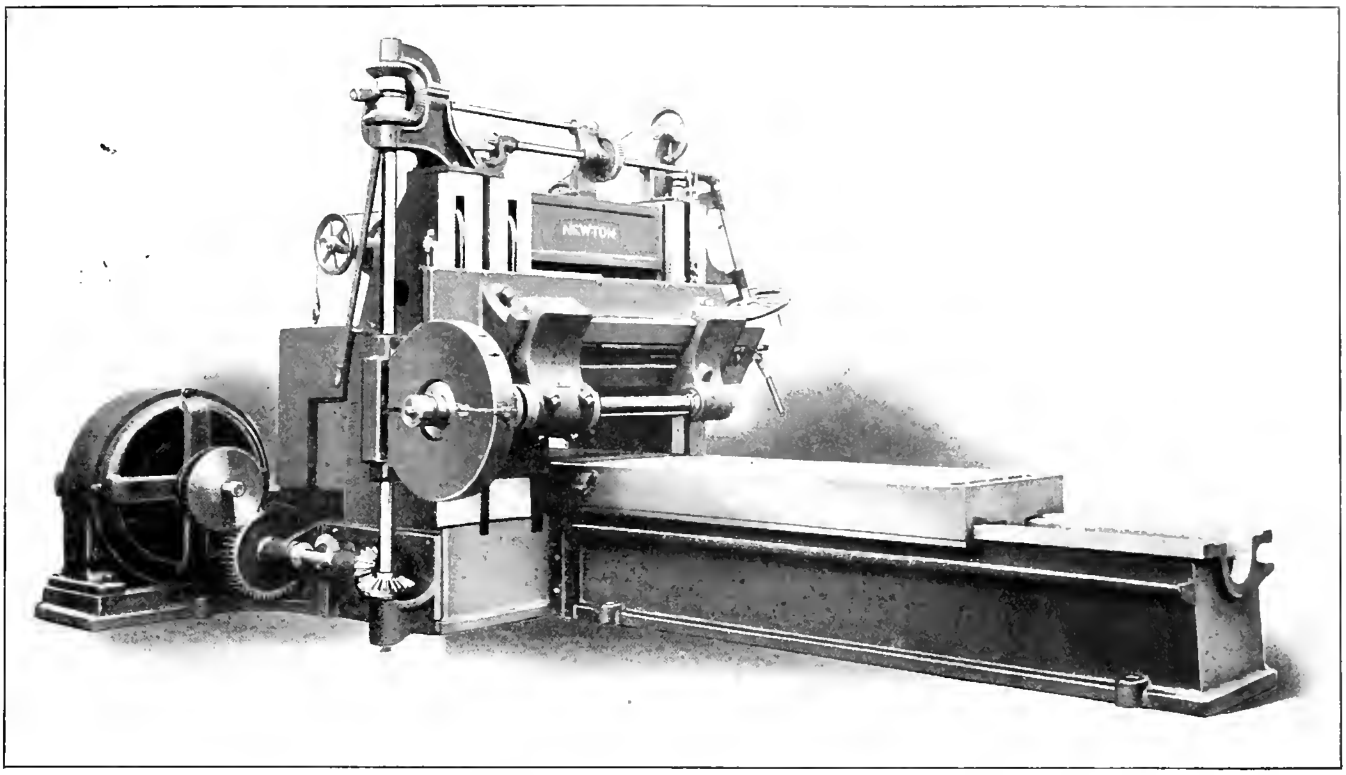
The illustrations show a heavy slab milling machine made by the Newton Machine Tool Works of Philadelphia, and especially adapted for railroad and locomotive shop usage. The spindle is $6\frac{1}{2}$ ins. in diameter and has a main bearing 15 ins. long. It is driven by a phosphor bronze worm wheel and a case-hardened steel worm of steep lead, having a roller thrust bearing. This is driven by a 35 h.p., 2 to 1, variable speed motor through a train of gearing, as shown in one of the illustrations. The driving worm and worm wheel have a ratio of 20 to 1. All gears are of steel. The spindle is reduced to 6 ins. in diameter at the worm wheel bearing and is keyed to it by a double spline. The spindle has a side adjustment of 8 ins. for convenience in setting the cutters after the work has been placed on the machine. The arbor is arranged to drive by a "butterfly key" (a slot across the face of the spindle). The outboard bearing for the arbor is bushed, the bushing being tapered on the outside and split to compensate for wear, as it is arranged to fit over the arbor bushings and be adjusted to support the arbor close to the work.



VARIABLE SPEED GEAR BOX FOR TABLE FEED.

The cross-rail has an inclined face, which in addition to carrying the spindle close to the uprights, overcomes to a very great extent the tendency of the cutter to "pull in" when milling a piece which has a surface of widely varying widths. It also reduces the tendency to chatter to a minimum.

The cross-rail has a bearing 25 ins. wide and 38 ins. long on the main upright, and 12 ins. wide and 31 ins. long on the narrow upright. The face of the cross-rail is 16 ins. wide and the center of the spindle is 4 ins. below the face of the rail in order to work around forged oil



HEAVY NEWTON SLAB MILLING MACHINE SHOWING APPLICATION OF MOTOR.

cups on connecting rods, or to be able to sink in and mill keyways on large diameter shafts having widely varying diameters, or other similar work. The cross-rail is counterweighted and has hand adjustment and a power quick movement in both directions.

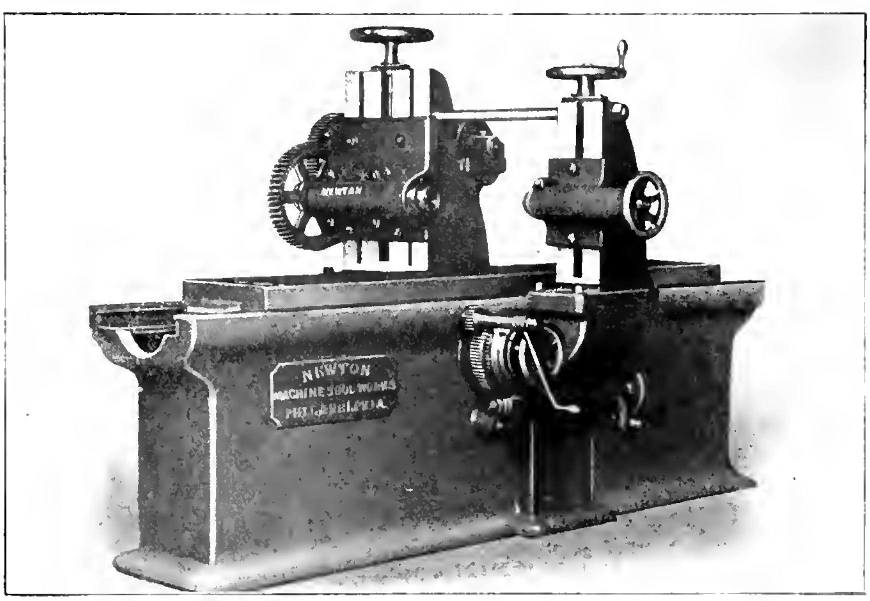
A special advantage and an important one for such work as fluting connecting rods, where it is necessary to sink the cutter from 1½ to 1¾ ins., is that the quick power movement is specially designed for this purpose. The cross-rail screws are arranged to pull the rail down into the work instead of pushing it, as is ordinarily done. This, in connection with provision which is made to prevent the table from pulling forward when sinking in, or working backward, due to the pulling of the cutter, overcomes the breaking of cutters and arbors and damage to the cross-rail.

The uprights are of extra heavy section and are 36 ins. deep. The carriage is 36 ins. wide and 7 ins. deep to mill 14 ft. in length. It has a bearing on the bed 29½ ins. wide and is operated by a steel rack 4 ins. wide and a bronze spiral pinion. Variation of the rate of travel or feed of the carriage is obtained by means of an easily controlled and compactly designed gear box, shown in one of the illustrations, for which a patent is pending. The gears in this box are all steel and run in oil. To distinguish the driving shaft a pulley has been placed on it. On this shaft are three gears on one sleeve which slide and mesh with the idle gears on the intermediate shaft, these in turn meshing with the sliding gears on the third shaft. The edges of the teeth are beveled in order that the gears may readily be changed from one position to another while running. The feed to the carriage of 1 to 10 ins. per minute is furnished with a quick power movement in both directions.

The following accounts of work, which are not record performances but have been done right along for a considerable time, show conclusively the advantages of the machine and the method of driving it. A cut 9½ ins. wide and 9/16 in. deep with a table feed of 8 ins. per minute was taken on a connecting rod. This is at the rate of 43 cu. ins. per minute or 1¼ cu. ins. per minute per rated horse power of the motor, which is said to exceed all previous records.

In another instance locomotive connecting rods have been fluted or channelled, two at a time, with cuts 3 ins. wide and 1½ ins. deep with a feed of 3¼ ins. per minute. The cutters used were of the inserted tooth type, with teeth of air hardened steel inserted on a true spiral. The cutters operated at a peripheral speed of 86 ft. per minute.

To give some idea of the advance in slab milling machine design, a machine made at the Newton Works in 1884 is illustrated. This machine was intended for the same class of

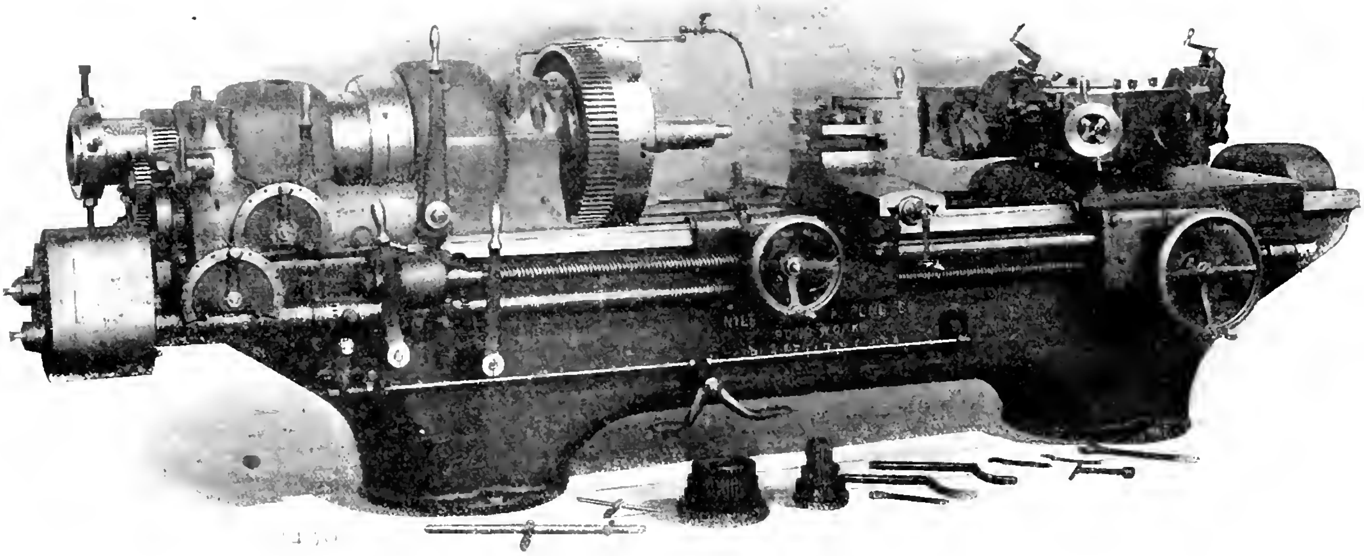


OLD TYPE NEWTON SLAB MILLING MACHINE—BUILT IN 1884.

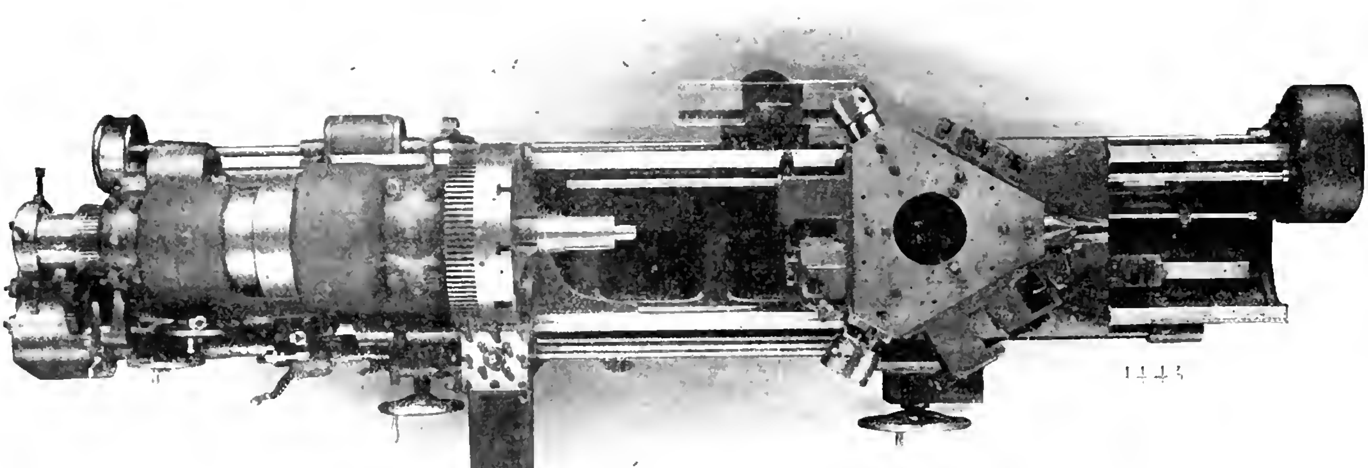
work as referred to above and is said to be the first commercially successful slab milling machine built. The table was of the inside square lock design in place of the overlapping square lock design in the later machines. The feed was controlled by a spur pinion and rack, quick power motion being obtained by the crank shown in the illustration, one turn of which advanced the carriage 7 ins. The spindle was driven by spur gears and the outboard bearing had to be adjusted independently of the main spindle bearing. In its day this machine was considered a record breaker.

POND "RIGID" TURRET LATHE EQUIPPED FOR BAR WORK.

The 28-inch Pond turret lathe, shown in the illustrations was originally designed for chucking work only, but largely due to the demands of railroad shop work has been equipped for bar work. The view looking down on the top of the machine gives a good idea of the rigidity obtained by the use of short turning tools, the die head being placed directly on the turret face without the intervention of the usual die holder,



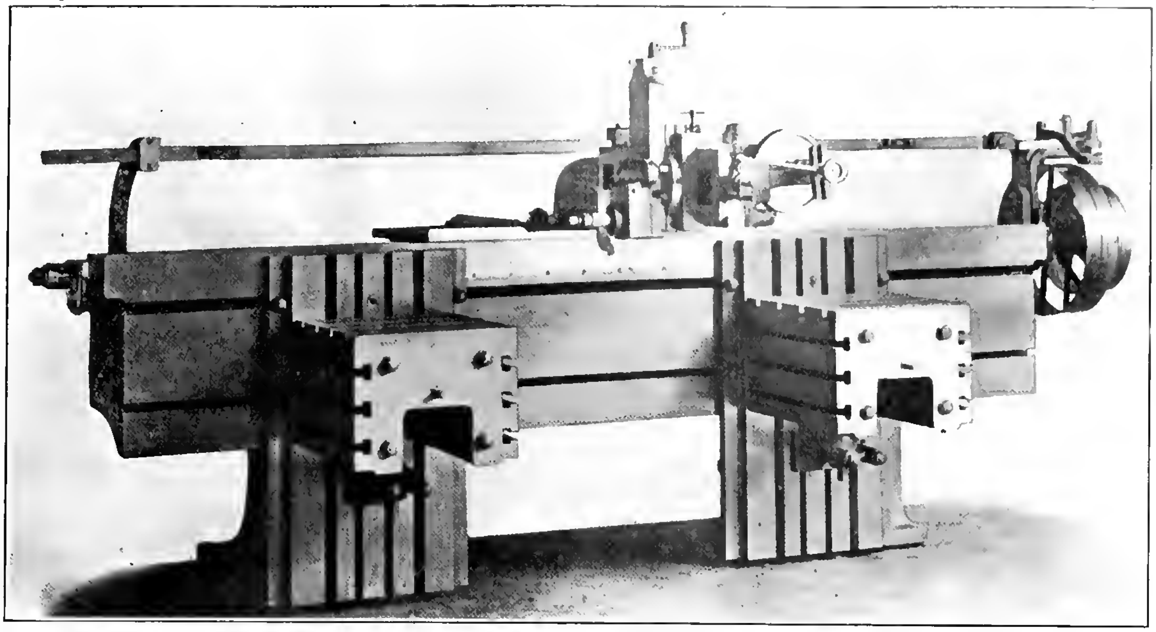
POND 28-INCH TURRET LATHE EQUIPPED FOR BAR WORK.



VIEW LOOKING DOWN ON TOP OF POND TURRET LATHE.

thus insuring perfect thread cutting within the limit of accuracy of the die head. Both the carriage and the turret are provided with six changes of feed, each being independent of the other and operated by different lead screws, so that, if desired, the work may be turned at the same time that it is being bored. When the cross carriage is not in use it may be moved to the left, as shown in the view looking down on the top of the machine. While in this position the turret may be brought close to the face of the chuck, making possible the use of short tools, which is a very desirable feature.

AMERICAN TRADING WITH THE LEVANT AND ITS POSSIBILITIES.—Mr. Aris. Tsakonas, M. E., 5212 Jefferson street, Philadelphia, is sending out to all American manufacturers who are interested, a pamphlet on the above subject. The excellent advice contained therein for the satisfactory marketing of machinery in the Levant has been drawn from a long personal experience in that section of the world as well as America. The reading of this pamphlet will be to the advantage of any firms considering a market in the Mediterranean district.



TRAVELING HEAD OPEN-SIDE PLANER—E. A. WALKER.

The turret is designed with very wide faces, making it possible to rigidly secure the heaviest tools. It rotates automatically and has a rapid power traverse in either direction. Independent stops are provided for each face, and it may be made to revolve at any desired point of its travel. The machine is designed for handling castings up to 28 ins. in diameter. The swing over the carriage arms is 26 ins. and over the cross slide 24½ ins. The lathe may be equipped with a 24-in. 3 or 4 jaw independent or combination chuck. The turret has a travel of 5 ft. The hole through the spindle is 4¼ ins. in diameter, and is counter-bored to 5 5/16 ins. for a distance of 12 ins. in order to permit boring bars with both roughing and finishing cutters to be used, the roughing cutter being inside the spindle, while the finishing cutter is at work. The compact and substantial design of this machine makes it especially advantageous for use in railroad shops.

STEEL PASSENGER CARS.—The operation of the steel passenger car shop did not contribute to the company's earnings, for the reason that education of men in a new line of industry is expensive and tedious, and full output of work cannot be secured by reason of the unfamiliarity of the workmen with the work; but we have gone far enough into this construction to know that, as a result of the operations to date, we can produce a first class fireproof passenger car with only a slight increase in weight over the present wooden type, but at an increased cost. The question as to how great will be the pecuniary benefit to accrue to the company from this department must be left to the future, as the railroads at the present time, when there is an urgent demand for better service, and the various State Legislatures are insisting on lower rates, naturally show hesitancy in doing anything that will increase the cost of their equipment. Our experience convinces us that until there has been a much larger volume of business presented, the cost cannot be substantially reduced. This company, by reason of its being a pioneer in the field, is necessarily in the front rank in this development, and so is prepared to furnish this fireproof passenger equipment whenever it can be sold at a reasonable profit.—*Report of Pres. Hoffstot of the Pressed Steel Car Co.*

RAILWAY STOREKEEPERS' ASSOCIATION.—The fourth annual meeting of this association will be held at the Auditorium Hotel, Chicago, Ill., May 20th, 21st and 22nd, 1907. The president is Mr. N. M. Rice, general storekeeper of the Santa Fe, and the secretary, Mr. J. P. Murphy, general storekeeper of the Lake Shore.

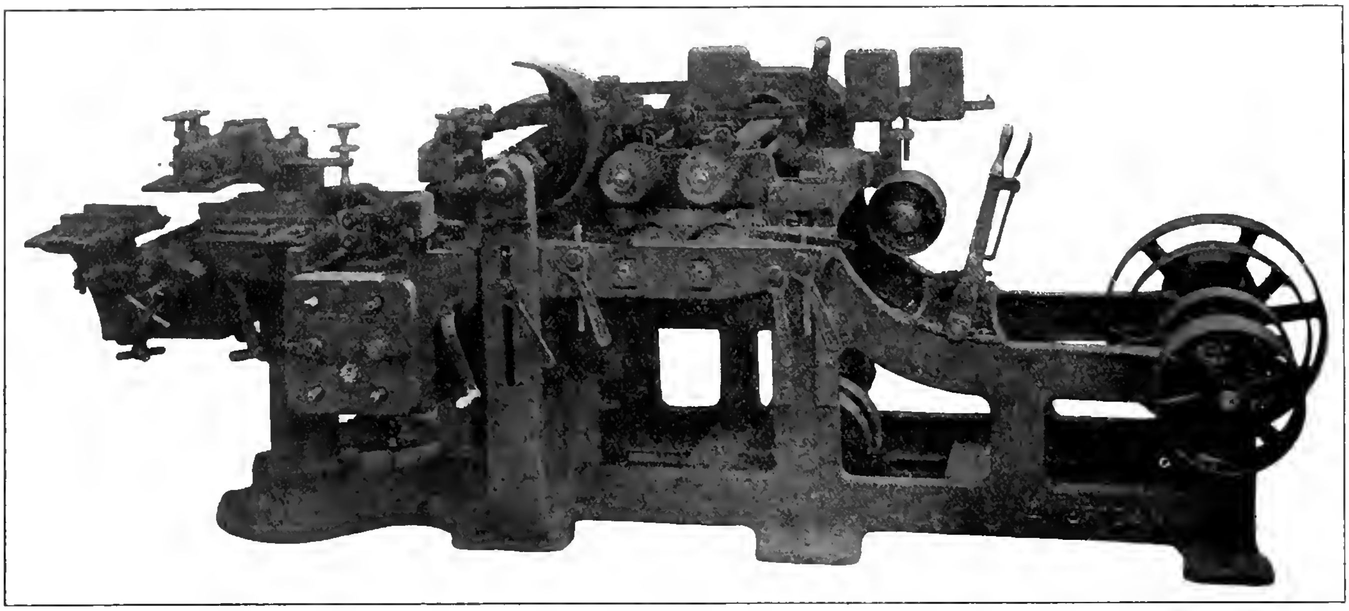
TRAVELINGHEAD OPEN-SIDE PLANER.

The traveling head open-side planer has many advantages for certain classes of work. The cutting tool travels instead of the work; the tool is carried by an overhanging arm; the traveling head is actuated by a screw; almost any piece of work, no matter how awkward, can be securely held in place by means of the slotted plates and the tables, and this is especially true if a pit is placed directly in front of the machine, thus making it possible to easily set in place and accurately plane with a minimum amount of power large and cumbersome pieces which it would be difficult to handle in a planer with its movable platen.

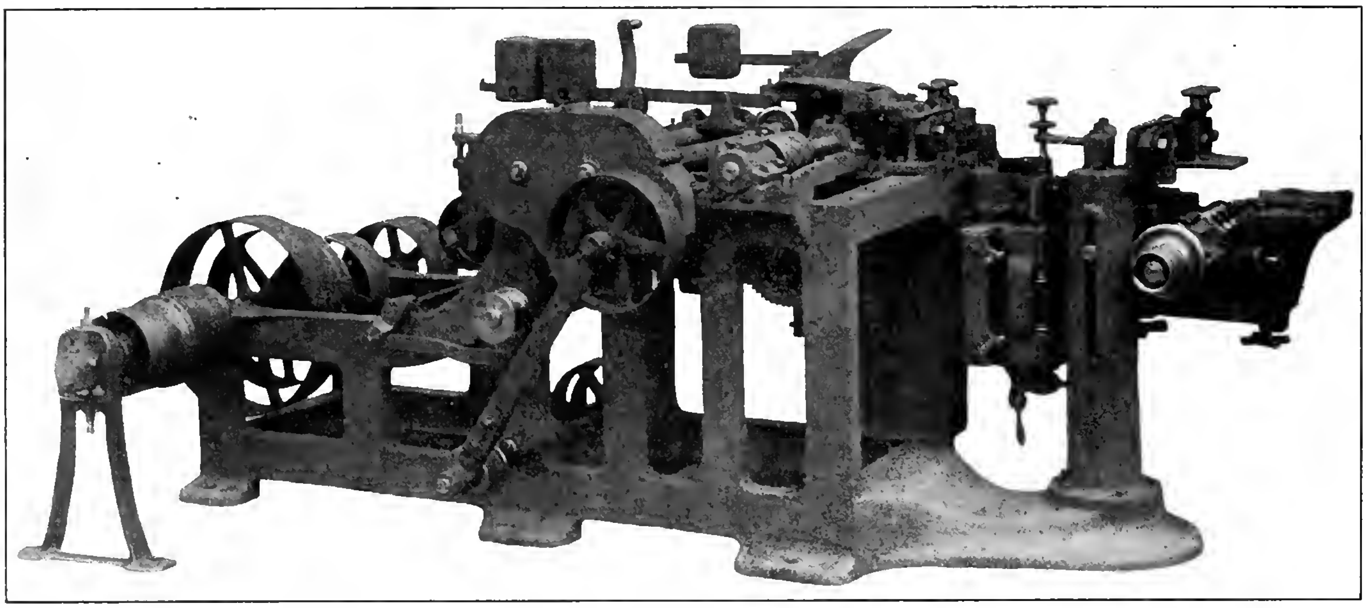
The machine illustrated is made by E. A. Walker, of Philadelphia, and is known as the Richards type. The table travels parallel to the bed, the tool carriage passing over such work as may be fastened to the slotted plates and tables. It will plane 8 ft. in length, has a cross feed of 25 ins., an angle or down feed of 12 ins., and weighs about 5 tons. The slotted plates are each 39 ins. long, 25 ins. wide and 3 ins. thick. The square tables are 15 x 19 x 22 ins. and have a vertical adjustment of 25 ins. A greater vertical adjustment may be arranged for by providing longer slotted plates. The distance from the floor to the underside of the crosshead is 42 ins.

Time may often be saved on certain classes of work by fastening one piece in place while another is being machined. If desired three tables may be provided, the third one often proving valuable, especially on the machines with larger beds. An idea of the wide range of work which may be handled to advantage on this type of machine is given in an illustrated booklet which may be obtained upon application to the manufacturer.

A SIMPLE DYNAMOMETER CAR can be constructed by strengthening the frame of an old passenger coach or even a caboose car, installing in it an hydraulic dynamometer, which can be purchased in the open market complete for about $250, and equipping the car with some form of speed indicator and recording machine that will be driven from the axle of the car and will have its paper travel so regulated that the draw-bar pull is plotted with relationship to the distance and speed. While many other features may be added to such a car, these are the essentials that are required for accurate work, and the whole arrangement, exclusive of value of the car used and the work done in strengthening the car, can be gotten up for $600 or $800.—*Mr. D. C. Buell, Central Railway Club.*



FRONT VIEW OF AMERICAN OUTSIDE MOULDER.



AMERICAN NEW 7 AND 8 INCH OUTSIDE MOULDER, REAR VIEW.

NEW AMERICAN OUTSIDE MOULDER.

On page 247 of our June, 1906, issue we described the new American four-column outside moulder, arranged for working all four sides of a piece 12 or 14 ins. wide by 6 ins. thick. These moulders had several important improvements over previous designs. The new features have given such general satisfaction that the more important ones have been incorporated in the design of the standard machines. The illustrations show one of these improved machines which will work four sides, 7 or 8 ins. wide by 4 ins. thick.

The frame is cast in one piece, making it solid and substantial and preventing any twisting, thus keeping all bearings in perfect alignment. The heavy column at the rear end of the machine furnishes a substantial support for the table and the under head. An outside bearing is provided for the support of the top arbor, which extends to the floor and is firmly bolted to the base of the frame, while at the top it is secured by a heavy bolt passing through the table and the frame. It is adjustable for lining up the head. The bed is heavy and well porportioned and is securely gibbed to a frame, with provision for taking up wear. It raises and lowers 12 ins. by a large steel screw on ball bearings, operated by a crank. There is a detachable bed plate directly under the top cutter head, reversible, one side plain, the other side grooved ½ in. deep and ½ in. apart, to allow the cutters to project lower than the bed. The extension of the bed, beyond the lower cutter head, drops down, giving free access to the cutter head without disturbing the guides. The bed carries the inside and outside headstocks which have also an independent adjustment.

The feed rolls are 5 ins. in diameter and have an improved direct gear drive for top and bottom rolls, making a positive and very powerful feeding device and rendering the use of heavy weights unnecessary. Four rates of feed are provided to meet the requirements of the purchaser. The top head has a lateral adjustment. The bottom head has both lateral and vertical adjustments, which are controlled by a hand wheel. The side heads rise and fall with the table, and can be set to an angle and moved vertically and laterally without changing the angle. The outside side head is arranged with an adjustable weighted chip breaker which travels with the head. The inside head can be adjusted from either the front or the rear of the machine. Both side heads may be adjusted, while the machine is in motion. An adjustable tightener is provided for the belt driving the top head, by means of which

the slack may be instantly taken up, and permitting no greater strain than necessary when running on the lighter class of work.

The bars that carry the adjustable pressure shoes, over the under cutter and directly back of the top cutter head, are hinged and may be thrown back; each pressure shoe can be set at an angle, and each shoe has its own independent adjustment. The chip breaker and hood for the top head may be thrown up and back across the machine, giving free access to the top head. All cutter heads are provided with vertical and lateral adjustments and have a normal cutting circle of 5⅞ ins. All cutter head chip breakers are adjustable and will allow the knives to extend 2 ins., giving a maximum swing of 9⅞ ins. These moulders may, if desired, be arranged for driving by individual motors of 10 h.p. capacity. They are made by the American Woodworking Machinery Company.

FINISHED REPAIR PARTS FOR LOCOMOTIVES.

The importance of carrying finished material in stock at railroad repair shops, in order that an engine coming in for repairs may be turned out with as little loss of time as possible, is coming to be quite generally recognized. It has been found advisable to centralize the manufacture of repair parts at a central point on large systems from which the finished material, as far as possible, is sent to the various repair points. It is true, however, that even at the main shops the manufacturing work takes second place, the repairing of locomotives being considered as of first importance. It has been suggested that the work could be done more cheaply in a separate plant, entirely separated from the repair department, where highly specialized machinery was used, and that if such a plant was operated by outside parties working in competition with other concerns, the material could be furnished to the railroads more cheaply than they could make it themselves, especially if the methods of accounting on the railroad and in the manufacturing shop were placed on the same basis, or in other words, if the railroad company made a proper allowance for the general expenses or surcharges. The railroad officials, relieved of this part of the work, could then devote their efforts to other and more important work.

In this connection it is interesting to note that a company known as the Locomotive Finished Material Company, located at Atchison, Kans., has just completed a plant and is now making delivery of finished locomotive castings.

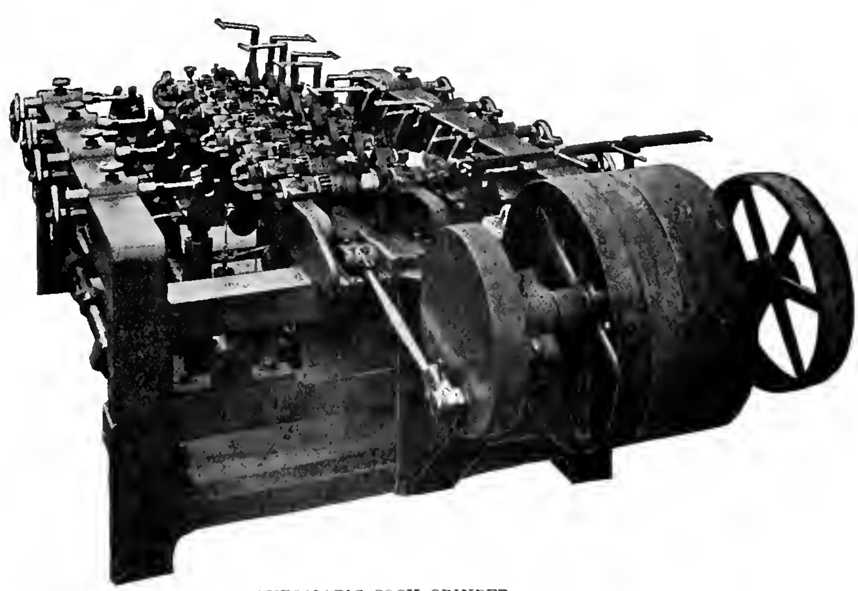
Castings for new work are finished complete to the drawings. Castings for repair work are finished to as great an extent as possible, leaving only the necessary stock for fits and wearing surfaces. As an illustration, cylinders are finished complete except the saddle; driving boxes are finished complete except for the hub faces and journal fit; shoes and wedges except for the driving box face; packing rings are finished complete; solid piston heads are finished, leaving sufficient stock for cylinder and rod fit; cylinder heads are finished complete; eccentric and eccentric straps are finished to standard dimensions or stock is left as specified.

As far as we know, this company is the first one which has been formed for the purpose of manufacturing finished locomotive castings, and it is understood that they already have several large orders. The president of the company, Mr. John Seaton, is also president of the Seaton Foundry Company of Atchison, which has furnished two of the large western railway systems with rough castings for the last thirty-five years. The general manager, Mr. H. E. Muchnic, has been connected with the mechanical department of one of the large railway systems and has a thorough knowledge as to railroad requirements and machine shop methods.

AUTOMATIC COCK GRINDERS.

The automatic cock grinder shown in the illustration was designed to quickly and accurately grind in the plugs or keys for brass cocks. It is made in two sizes by the Turner Machine Company, 2049 North Second Street, Philadelphia. The larger size, or No. 2 machine, which is shown in the illustration, is adapted for cocks up to 3 ins. in size. It has eight spindles, requires two operators, and is said to be able to grind eight hundred ¾-in. cocks per day. At any time that it is desirable four of the spindles may be cut out of service and the machine may be operated by one man.

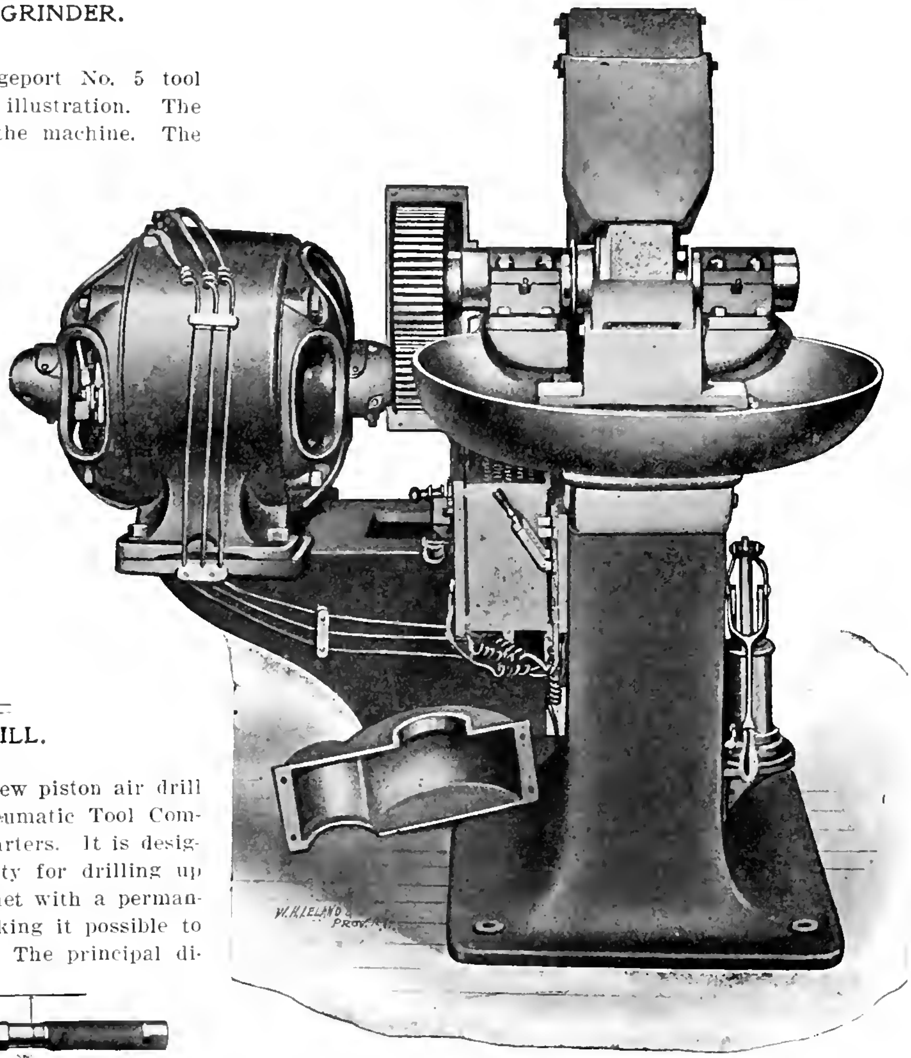
The No. 1 machine has four spindles, requires only one operator, will grind all sizes of cocks up to 2½ ins., and will grind as many as four hundred ¾-in. cocks per day. The barrel of the cock is held by an adjustable holder, the adjustment allowing an expansion vertically or laterally, in order to take the different sizes of cocks. The plug is held between centers, adjustment of the length of the spindles being made by a quick turn or thrust of the spindle, which is knurled at the operating end. Locking is effected by means of a lever stop at the side of the spindle. The head of the plug is held by dogs. The barrel of a cock may be held rigidly within its holder if desired, but generally a little play is allowable. The action of alternately forcing the plug into the barrel for grinding and withdrawing it is accomplished by cams and counterweights, the barrel being forced on by the counterweights and withdrawn by the cams. The spindles are operated by cut gears and a bronze cut rack, and make seven-eighths of a turn in each direction. Any spindle may be instantly thrown out by means of friction clutches operated by the levers seen above the bed plate. The connecting rod is of steel, fitted with brass boxes, the bearings for the driving shaft being babbitted. A pulley at the left of the driving shaft operates the cams. In action the machine is said to be noiseless.



AUTOMATIC COCK GRINDER.

BRIDGEPORT MOTOR DRIVEN GRINDER.

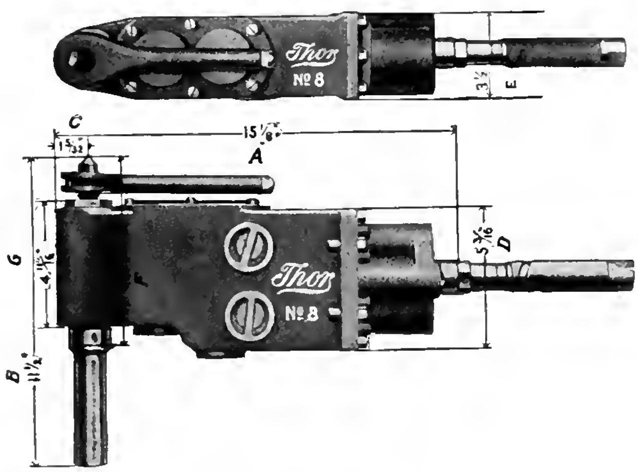
A typical motor application to a Bridgeport No. 5 tool grinder is shown on the accompanying illustration. The motor bracket is cast on the column of the machine. The motor, which may be of a make suitable to the purchaser, is back geared to the emery wheel spindle with a ratio of about 3 to 1. The gears are encased and the grinder spindle bearings are self-oiling. A 5-h.p. motor is used, and the emery wheel, 36 ins. in diameter with a 4-in. face, is operated at a speed of 425 r.p.m. The floor space occupied by the machine is 30 by 47 ins., and its weight complete is 2,650 lbs. The motor is controlled by a starting box, but ordinarily this is not used except at the beginning and end of the working day. These machines are made by the Bridgeport Safety Emery Wheel Company, Inc., Bridgeport, Conn.



MOTOR DRIVEN GRINDER.

CLOSE QUARTER AIR DRILL.

The accompanying illustration shows a new piston air drill recently perfected by the Independent Pneumatic Tool Company for work in corners or other close quarters. It is designated as "Thor" No. 8 and has a capacity for drilling up to a 2½ in. hole in any material. A ratchet with a permanent handle is fitted on the feed screw, making it possible to drill or ream in very inaccessible places. The principal dimensions are shown in the illustration. One of these drills will be sent on approval to anyone desiring to make a test of its capabilities.



PNEUMATIC DRILL FOR CLOSE QUARTERS.

Equipment Mileage.—Tables just compiled by the Pennsylvania Railroad, Lines East of Pittsburgh and Erie, show that the total freight equipment mileage—the number of miles traveled by all freight cars—amounted in the year 1906 to 1,329,259,529, an increase of 18 per cent. in two years. The passenger equipment mileage was 185,287,826, an increase of 12.4 per cent. in two years, and the locomotive mileage, both freight and passenger, was 120,824,079, an increase of 17.8 per cent. in two years.

Growth of freight traffic, as shown by the figures, was especially large on the Pennsylvania Railroad Division and the Buffalo and Alleghany Valley. The increase in freight equipment mileage on the latter amounted to 33 per cent. in two years. The record of the P. R. R. and B. & A. V. Divisions for the three years ending December 31, 1906, were as follows:

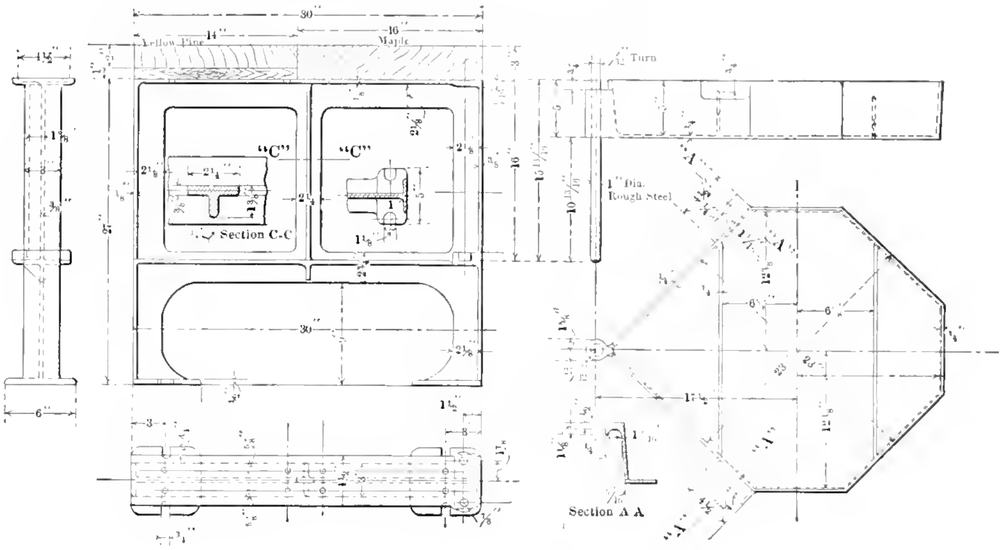
	P. R. R.	B. & A. V.
1904	655,425,683	86,801,849
1905	747,900,477	105,947,065
1906	780,870,162	115,754,503

The folowing figures show the locomotive mileage and the passenger equipment mileage for the three years:

	Locomotive.	Passenger Equipment.
1904	102,530,756	164,907,195
1905	113,533,613	172,181,392
1906	120,824,079	185,287,826

Free Advertising.—Hundreds of concerns try to get notice in their trade press without giving up any information worth reading. With the fear of competitors in view, they never reason that the competitor who is really alive, and dangerous, and able to use information, will probably get all the data he wants whether they give it out or not. They fail to see that the concern contributing valuable information regularly to technical publications soon becomes known as one conspicuous for its activity and progressiveness. They would like the trade to believe, in effect, that the total result achieved by a high-priced executive, investigating and manufacturing staff the past six months is that:

Thomas F. Jones, president of the American Mill Construction Corporation, visited New York last week on business connected with the company.—*Mr. James H. Collins in Selling Magazine.*



BENCH DRAWER.

BENCH DRAWER.

A bench drawer, far superior to the ordinary type, has been in use in the works of The G. A. Gray Company, Cincinnati, for several years with very satisfactory results. The drawer is of cast iron, swings on a vertical shaft, thus opening easily and swings wide open, making every part of the drawer available and open to inspection without danger of spilling the contents. The drawer was originally designed by Prof. John E. Sweet. The accompanying drawings show a modification of the design as adopted by The Gray Company.

As may be seen, the cast iron bench legs, which are placed about 6 feet, center to center, are designed to take the vertical shafts upon which the drawers swing. The upper part of the shaft is turned to 27-32 in. in diameter and fits in the ⅞-in. drilled hole in the bench casting. The lower end of the shaft is 1 in. in diameter and rests in a slot in a projection or bracket on the leg of the casting. The arrangement of the slot and the manner in which the door operates are such that there is no liability of the lower end of the shaft being displaced. The sides and bottom of the drawer are ¼ in. thick, and if desired may be lined with wood or other material. The bench covering used by The Gray Company consists of 3-in. x 16-in. x 12-ft. maple planks at the front of the bench, and 2-in. x 14-in. yellow pine planks at the rear resting on 1-in. strips placed lengthwise on the castings.

We are indebted to The G. A. Gray Company for drawings and information.

Grammar.—The tendency to place grammar at the head of the list of requirements in contributed matter, or in any prominent place in such a list is really amusing to an editor. The grammar and the spelling of an article are nothing but the paint and polish, which it is perfectly easy to find someone to put on, while the man for whom we are looking is the one who can do the really important work. Grammar is like a man's necktie which, though necessary for the sake of appearances, does little that is really useful. We wish our doubting readers could see some of the manuscript that comes into this office and know some of the sources from which it comes. If our readers imagine that all college professors can write English which would be presentable in type, they are very much mistaken, the fact being that manuscript from such sources requires editorial revision to a degree that they would scarcely believe. And does the editor buy a larger hat when he corrects the manuscript of a professor? No, because the printer and the proofreader even up the matter with him by correcting his manuscript in turn.

There is not one college graduate in twenty—we would put the figure higher if we thought that we would be believed—who can prepare manuscript that he would not himself be ashamed of, could he see it reproduced in type exactly as he prepared it; the queer thing about it being that errors which entirely escape one's eye in the manuscript will stare him out of countenance from the printed page. The niceties of printed English are found in no grammar and taught in no school. The printer and the professional English scholar are the only ones who know them, and in a contest between the two we would lay long odds on the printer winning.—*American Machinist.*

Standardization of Locomotives.—It would be absurd and immensely unprofitable to displace all existing engines with new standard ones, for the double reason that the old engines are in a majority of cases able to render good and efficient service, and the new standardized engines would in the course of five years themselves be obsolescent. Moreover, such thorough standardization as hereinbefore indicated will apply in whole to but 30 to 50 per cent. of the engines, although these engines move 75 to 80 per cent. of the traffic. It can only be hoped that standardization will be approximately complete. In the course of time and as experience and recent development dictate, these standard parts themselves must undergo redesign. But it may be hoped that for the greater part the feature of interchangeability will be retained, and the feature of central manufacture in quantities will be one of the governing considerations in design and redesign.—*Mr. H. W. Jacobs in the Engineering Magazine.*

PERSONALS.

Mr. J. J. Curtis has been appointed master mechanic of the Chicago Union Transfer Railway, with office at Clearing, Ill.

Mr. W. W. Thomas has been appointed master mechanic of the St. Louis & San Francisco Ry., at Cape Girardeau, Mo.

Mr. T. F. Carbery has been appointed division master mechanic of the Missouri Pacific Ry. at St. Louis, Mo.

Mr. J. S. Sheafe has been appointed general foreman of the Indianapolis Southern Ry. shops at Indianapolis.

Mr. L. A. Litterer has been appointed road foreman of engines of the A. T. & S. F. Ry. (Coast Lines) at Needles, Cal.

Mr. Wm. Henry has been appointed assistant master mechanic of the St. Louis & San Francisco Ry. at Memphis, Tenn.

Mr. I. C. Hicks has been appointed master mechanic of the Los Angeles division of the A. T. & S. F. Ry., at San Bernardino, Cal.

Mr. P. C. Morales has been appointed acting master mechanic of the Vera Cruz & Pacific R. R., with office at Tierra Blanca, Mex.

Mr. Isaac McKeever has been appointed master mechanic of the L. V. R. R., at Weatherly, Pa.. succeeding Mr. Thomas Coyle, deceased.

Mr. Wm. Schlafge, master car builder, has been appointed general master mechanic of the Erie R. R. with headquarters at Meadville, Pa.

Mr. Chas. A. Bingaman has been appointed engineer of tests of the P. & R. Ry. instead of Chas. A. Bingham as noted in our last issue.

Mr. J. T. Johnston has been appointed assistant general boiler inspector of the A. T. & S. F. Ry., with headquarters at Albuquerque, N. M.

Mr. A. B. Todd has been appointed master mechanic of the Valley division of the A. T. & S. F. Ry. (Coast Lines) with office at Richmond, Cal.

Mr. O. R. Hale has been appointed master mechanic of the Torreon division of the Mexican Central Ry., with headquarters at Torreon, Mex.

Mr. N. Greener, master mechanic of the Tremont & Gulf R. R. has been appointed superintendent of motive power, with office at Tremont, La.

Mr. R. T. Jaynes, general shop foreman of the Lehigh & Hudson River R. R., has been appointed master mechanic, with office at Warwick, N. Y.

Mr. A. E. Mitchell has been appointed expert engineer of tests of the New York, New Haven & Hartford Ry., with headquarters at New Haven, Conn.

Mr. E. H. Harlow has been transferred to Albuquerque, N. M., as master mechanic of the first district of the Albuquerque division of the A. T. & S. F. Ry.

Mr. R. G. Long has been appointed division master mechanic of the Missouri Pacific Ry. at Fort Scott, Kans., succeeding Mr. W. C. Walsh, resigned.

Mr. J. R. Bancroft has been appointed general foreman of the shops of the Houston & Texas Central at Houston, Texas, in place of Mr. D. E. Bloxsom, resigned.

Mr. A. R. Manderson has been appointed master mechanic of the Portland & Rumford Falls Ry. at Rumford Falls, Me., succeeding Mr. M. R. Davis, resigned.

Mr. F. S. Guinn has been appointed road foreman of engines of the first district of the Arizona division of the A. T. & S. F. Ry. with headquarters at Needles, Cal.

Mr. G. W. Lillie has been appointed supervisor of the car department of the St. Louis & San Francisco Ry., with office at St. Louis, Mo., succeeding Mr. C. D. Pettis, resigned.

Mr. A. H. Hodges, heretofore general foreman at Brunswick, Md., has been appointed master mechanic of the Cumberland division of the B. & O. R. R. at Cumberland, Md.

Mr. E. A. Westcott, heretofore foreman of car repairs at Kent, Ohio, has been appointed assistant mechanical superintendent of the Erie R.R. in charge of the car department.

Mr. T. Rumney, heretofore assistant mechanical superintendent of the Erie R.R., has been appointed mechanical superintendent, succeeding Mr. George W. Wildin, resigned.

Mr. W. M. Evans, general foreman of the C. R. I. & P. shops at Herrington, Kan., has been appointed master mechanic at Argenta, Ark., to succeed Mr. J. M. McGie, promoted.

Mr. M. J. McGraw, heretofore master mechanic of the Missouri Pacific Ry. at St. Louis, has been transferred to Sedalia, Mo., as superintendent of shops in place of Mr. S. M. Dolan, resigned.

Mr. A. E. Jarrett, general foreman of the L. & N. R. R., at Nashville, Tenn., has been appointed assistant master mechanic at Birmingham, Ala., succeeding Mr. J. P. Fahey, deceased.

Mr. G. J. DeVilbiss, master mechanic of the Newark division of the B. & O. R. R., has resigned to accept the position of superintendent of motive power of the Ohio Central Lines, with office at Columbus, Ohio

Mr. R. H. Rutherford, heretofore master mechanic of the Mexican Central Ry., at Torreon, Mex., has been appointed master mechanic of the Aguascalientes division, with headquarters at Aguascalientes, Mex.

Mr. J. Kirkpatrick, heretofore master mechanic of the Cumberland division of the B. & O. R. R., has been appointed master mechanic of the Newark division at Newark, Ohio., in place of Mr. G. J. DeVilbiss, resigned.

Mr. Maurice Dailey, master mechanic of the Des Moines division of the Chicago Great Western, with office at Des Moines, Ia., has been appointed superintendent of terminals of the Oelwein division, with headquarters at Oelwein, Iowa.

Mr. R. M. Galbraith, formerly general master mechanic of the St. Louis Southwestern Ry., which position he resigned in November, 1899, has been appointed superintendent of machinery of the Kansas City Southern Ry. with heeadquarters at Kansas City, Mo., to succeed Mr. F. Mertsheimer, resigned.

Mr. S. S. Stiffey, superintendent of motive power of the Ohio Central Lines, consisting of the Hocking Valley, the Toledo & Ohio Central, the Kanawha & Michigan and the Zanesville & Western, has been appointed general superintendent of motive power of these roads, with headquarters at Columbus, Ohio.

Mr. Joel Stephen Coffin.—Friends of Mr. Coffin, and he is held in high esteem by a wide circle of acquaintances among railroad men, will be glad to learn of his promotion to the position of vice-president of the Galena-Signal Oil Company. Mr. Coffin was born in 1861, and in 1876 entered the shops of the Chicago & West Michigan Railroad at Muskegon, Mich. In 1880 he started firing on that road and in 1881 was promoted to the position of engineer. In 1884 he took a position as engineer on the Wisconsin Central, and in 1889 was promoted to general road foreman of engines. In 1892 he entered the service of the Galena-Signal Oil Company as a mechanical expert, and in 1897 was made manager of the expert department, which position he has held to the present time. His office will, as before, be at Franklin, Pa.

BOOKS.

Proceedings of the Railway Signal Association for the Year 1906. Volume IX. Published by the Association, 12 North Linden street, Bethlehelm, Pa. 6 by 9 ins. Paper. 342 pages.

This volume contains the proceedings of the two Chicago and the two New York meetings and also of the annual meeting held at Washington, D. C., October, 1906. Several important individual papers were presented, and these with the committee reports and

the discussions form a valuable addition to the literature on this subject.

Proceedings of the Association of Railway Superintendents of Bridges and Buildings. Sixteenth Annual Convention held at Boston, Mass., October, 1906. 6 x 9 ins. 300 pages. Secretary, Mr. S. F. Patterson, Concord, N. H.

In addition to the discussion of standing subjects there are reports and discussions on the following topics: modern coaling stations and cinder pits, fire protection, preservatives for wood and metals, bumping blocks for passenger and freight use, method of watering stock in transit, recent practice in coffer dam work and pile and frame trestle bridges.

Traveling Engineers' Association. Proceedings of the Fourteenth Annual Convention. 1906. Edited by W. O. Thompson, secretary, Oswego, N. Y.

This volume contains the complete papers, together with a discussion thereof, presented at the last annual convention of the association, held in Chicago, August, 1906. It contains valuable papers on the subject of drafting locomotives, tonnage rating, handling of the air brake, Walschaert valve gear, a brief resumé of each annual convention since the founding of the association in 1893, together with the subjects discussed and the photographs of all of the past presidents. There is also included a list of active, associate and honorary members, which now number 587.

Mechanical Engineering Materials. By Edward C. R. Marks. 4¾ x 7 ins. Cloth. 98 pages, 38 illustrations. Published by The Technical Publishing Company, Ltd., 287 Deansgate, Manchester, England. Price, 2s. 6d.

This little book is not intended as an exhaustive treatise on the strength of materials but deals briefly with the properties and treatment in construction of the more common engineering materials. It is intended primarily to assist the user in making a proper selection from the various grades of materials on the market. It includes chapters on cast iron, wrought iron, steel, casehardening and Harveyizing, and the last two chapters consider copper, brass, bronzes, aluminum and white metals for bearings.

The Science Year Book. Edited by Major B. F. S. Baden-Powell. Published by King, Sell & Olding, Ltd., 27 Chancery Lane, W. C., London, England. 6 by 9 ins., cloth. Price, 5s.

The first part of this book, about 150 pages, is devoted to astronomical data; general information concerning the earth and climatic conditions; physical and chemical notes; metrology; a summary of the progress of science during the past year; a glossary of recently introduced scientific terms and names; directories of scientific and technical periodicals, British public institutions, offices and universities and British, American and Canadian scientific societies; and a biographical directory of scientists. The remainder of the book, about 400 pages, is a diary for 1907, although copies of the book may be obtained without the diary, if desired.

The Peabody Atlas. By A. Bement. 16¾ x 18 ins. 149 pages. Cloth. Published by the Peabody Coal Company, Chicago. Price, $5.00.

This volume contains much valuable information and interesting data relative to the bituminous coal mining industry of the central part of the country, including the States of Missouri, Illinois, Iowa, Indiana, Michigan, Ohio and part of Kentucky. It contains numerous colored maps showing the coal areas of this section, upon which is shown the location of each individual mine, together with its output, operator, etc., the railroad lines serving them and similar valuable information. There is much interesting data on the chemical, geological and engineering features of coal mines. A chapter is devoted to smokeless furnaces and smoke suppression, illustrated with photographs and sectional drawings showing the latest improved methods. This work will be found of much value to any one interested in this subject.

A Manual of Round and Square Bars, Turnbuckles, Clevis Nuts and Forgings. Flexible leather binding. 4 x 6¾ ins. 80 pages. Published by the Cleveland City Forge & Iron Company, Cleveland, Ohio.

This little handbook contains a considerable number of useful tables and information relating to round and square bars, turnbuckles and clevis nuts, and other forgings as made by the above company. It is intended as a manual for the use of engineers, car builders, architects and mechanics. Eleven pages are devoted to turnbuckles, and this includes such information as tables of dimensions, weights and price lists and illustrated descriptions of the various types. Following this is information concerning clevis nuts; car forgings, including brake and push rod jaws and drawbar yokes; counter and lateral rods; lateral and bridge chord pins with reversed screw ends for round bars; standard screw threads; dimensions of bolts and nuts; tables of information concerning square and hexagon nuts, washers and bolts; standard decimal gauge; wire and sheet metal gauges; weight and areas of square and round bars; decimals of a foot for each 1/64 of an inch; and decimals of an inch for each 1/64. In addition to a very complete index there is an illustration of the largest turnbuckle ever made, which weighed 768 lbs. and was tapped for 5-inch rods. There are also about 25 pages of cross-section note paper. It is presumed that copies may be had free, upon application to the above company.

Locomotive Performance. By W. F. M. Goss, M. S., D. E., Dean of Schools of Engineering, Purdue University. 6 x 9 ins. 439 pages, 229 illustrations. Cloth. Published by John Wiley & Sons, 43 East 19th Street, New York. Price, $5.00.

For a number of years the Engineering Laboratory of Purdue University has concerned itself with problems relating to the performance of locomotives, and the results of its researches have from time to time appeared in the proceedings of various scientific and technical societies. This process of publication has extended over a period of fourteen years, and has run through many different channels, with the result that the record now exists in widely scattered parts, which are often difficult of access and, therefore, of limited usefulness. The purpose of this volume is to combine the most important of these results with other material not before published, and thus make a permanent and accessible record of the work of the laboratory. The volume is designed as a record rather than a text, though it is hoped that it will prove of interest and value to any who wish to increase their acquaintance with the action of steam locomotives.

The book in addition to containing a brief review of the many important tests made on this plant with references by which the complete report on each may be obtained, together with the results of practical value, also gives a historical account of the Purdue testing plants and a complete description of the plants and locomotives on which tests were made. A final chapter is given in which the practical value of the results in making estimates of locomotive performance is clearly illustrated. This volume, taken in connection with the results obtained on the Pennsylvania R. R. Testing Plant at St. Louis, makes available for convenient reference all of the important data from accurate tests on American locomotives.

Proceedings of the Railway Storekeepers' Association. Third Annual Meeting held at Chicago, May, 1906. Cloth. 6 x 9 ins. 212 pages. Secretary, Mr. J. P. Murphy, Box C, Collinwood, Ohio.

The president reported that the membership had been increased to 184, an increase of very nearly 60 per cent. since the previous meeting. A number of valuable papers were presented and, what is more important, they were all freely discussed. This was especially true of the first subject on the program: "To what extent is the modern railroad storehouse a factor of economy?" Among the other topics were: Tidiness in the storage of, and caring for, material and its effect upon the future storekeeper; requisitions—the best and most simple form, also the method of recording and filing them; requisitions—the shortest method of handling at the general storehouse; rules governing division or terminal storekeepers; method of checking intake and output of material delivered to the shops; manufactured material—method of ordering and receiving in the company's shop; storehouse furniture; checking receipt of oils and paints; method of allowing scrap credit; stock record—simple and practical system of keeping; locomotive firebrick and asbestos lagging; railroad storehouse organization; storehouse economy, etc. The proceedings also include reprints of two papers, read before railroad clubs during the year, and the discussions which took place. One of these, "A True Perspective of the Supply Department," was presented by Mr. Geo. Yeomans before the Western Railway Club; the other, "The Railway Store Department and its Relationship to Other Departments," was presented by Mr. J. H. Callaghan before the Canadian Railway Club. In addition to the drawings and photographs reproduced in connection with the different papers there are twenty-five halftone illustrations showing various features in connection with the storehouses on the Santa Fe, Canadian Pacific, Lake Shore, New York Central and the North-Eastern of England. The as-

sociation is to be congratulated, not only on the high quality of the material in the proceedings, but upon its careful arrangement and the very neat and businesslike appearance of the volume.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

Steam Turbines.—The Kerr Turbine Company, Wellsville, N. Y., is issuing Bulletin No. 2, illustrating and describing the Kerr steam turbine blower. Details of the turbine are illustrated and the complete apparatus is very carefully described.

Lubricating Oil Storage.—S. F. Bowser & Company, Fort Wayne, Ind., is issuing a small folder illustrating several different arrangements and types of cabinets for oil storage suited to special conditions. These employ the Bowser self-measuring pump.

Gas Producers.—The Wellman-Seaver-Morgan Company, Cleveland, is issuing circular No. GP-1, which carefully illustrates and describes the Hughes continuous gas producers. It contains, in addition to the description, several comparative statements of investment and cost of operation of different types of gas producer plants.

Direct Current Motors and Generators.—Bulletin No. 1057 from the Allis-Chalmers Company, Milwaukee, Wis., describes their type K motors which are especially designed to meet the requirements for individually driving machine tools of all kinds. A number of applications to machine tools are illustrated. These motors operate exceptionally well as generators.

Machine Tools.—The March issue of the Progress Reporter published by the Niles-Bement-Pond Company describes and illustrates the following tools which are adapted to railroad shop work: Pratt & Whitney 16-in. toolmaker's lathe, planers with pneumatic clutches, Pond 28-in. turret lathe adapted for both chuck and bar work, two spindle cylinder borer, 600-ton hydraulic wheel press, double axle lathe, Pratt & Whitney improved tube expanding tool and a two spindle drill for locomotive work.

Electrical Apparatus.—The General Electric Company is issuing several new bulletins of interest to railroad men, those received being as follows: Bulletin No. 4486 on the CQ motor adapted for individual and group driving of machine tools; No. 4484 on railway signals of the two and three position type, electrically operated; No. 4481 on signal relays and No. 4482, a guide to the design of medium and small capacity central station switchboards.

Carey Roofing.—The Philip Carey Mfg. Co., Cincinnati, O., is issuing an attractive catalog descriptive of the Carey roofing. The materials entering into its composition are each considered and the favorable results accompanying the long time tests of this roofing under the most disadvantageous circumstances are explained by the fact that none but the best materials are used, which together with good workmanship and special methods produce a flexible fire and weather resisting product.

High Speed Steam Engines.—The American Blower Company, Detroit, Michigan, is issuing catalog No. 206, which is arranged and printed in a very neat and artistic manner and contains complete illustrations and description of several different types of small high speed engines, these being in the most cases automatic and designs are shown for both high and low pressure. They will run continuously for three months or more with no attention other than to fill the sight feed cylinder lubricator, and some have run as long as twenty-four months. Designs are shown in both the single and double cylinder type for driving blowers, electric generators or centrifugal pumps.

Alternating Current Generators.—The Crocker-Wheeler Company, Ampere, N. J., is issuing Bulletin No. 74 which is confined exclusively to a description of alternating current generators direct driven by steam, gas or oil engines. The details of machines are illustrated and each carefully described. A number of illustrations of recent installations are also included. One of the marked peculiarities of these alternators is their ability to operate in parallel, and it is stated that it was largely for this reason that the California Gas and Electric Corporation installed three 4,000 k. v. a. machines in its San Francisco plant. These are the largest generators ever built for gas engine drive.

Air-Cooled Electric Tools.—The Chicago Pneumatic Tool Company is issuing Catalog No. 21 which covers the complete line of electric drills, grinders, drilling stands, magnetic old man, hoists, etc., manufactured by it. The electric machines are of the Duntley air-cooled design and the catalog is profusely illustrated with half-tone engravings, showing the different tools in use. It also contains sectional drawings which show the construction and arrangement of the 1, 2 and 3 motor types of drills. These drills are manufactured for use with both direct and alternating current and in practically any size desired.

Ten-Wheel Type Locomotives.—A pamphlet just issued by the American Locomotive Company illustrates and describes ten-wheel locomotives weighing over 150,000 pounds. It is a sequel to the pamphlet issued last month by the same company describing lighter designs of this type. Thirty different designs are illustrated and the principal dimensions of each given. These range in weight from 152,000 to 201,000 pounds and are adapted to a wide variety of road and service conditions. This is the sixth of the series of pamphlets which is being issued by this company and which now includes pamphlets on the Atlantic, Pacific, Consolidation and Ten-Wheel types of locomotives.

NOTES.

Pressed Steel Car Company.—Mr. F. B. Bissell has obtained a long leave of absence from the above company and sailed on January 22 for a trip around the world.

Warner & Swasey Company.—Mr. Thomas Farmer of Detroit, Mich., has accepted a position with the above company as its western representative. The general office of the company is at Cleveland, Ohio.

Falls Hollow Staybolt Iron for French Locomotives.—The Paris-Orleans Railway Company of France has specified Falls Hollow Staybolt iron for the 20 DeGlehn compound locomotives now being built by the Baldwin Locomotive Works.

Crane Company.—This company announces that it now has its new steel foundry in full running order. In this department steel valves and fittings will be a specialty and the facilities are such that promptness in filling orders for these goods is assured.

Standard Coupler Company.—This company announces that Mr. Edmund H. Walker, who for the past two years has been assistant to the president, has been promoted to the position of general sales manager, with office at 160 Broadway, New York.

Kennicott Water Softener Company.—This company announces that it has recently received an order from the Baltimore & Ohio Railroad Company for a softener, having a treating capacity of 40,000 gals. per hour, which is to be installed at East Side, Philadelphia, Pa.

American Steam Gauge & Valve Mfg. Co.—It is announced that Mr. R. M. Turner, heretofore eastern representative, has been appointed manager of the publicity department of the above company. Mr. C. H. Mosher, who has had several years' experience in this line of work, will succeed Mr. Turner as eastern representative. The address of the company is 208 Camden St., Boston, Mass.

Crocker-Wheeler Company.—It was announced at the officers' and branch managers' convention of the above company, held January 23 to 26, that the company had done more business during 1906 than any other year since its foundation eighteen years ago. Among the specialties that made phenomenal successes during the year were alternating current generators of large capacity and direct current motors for machine tools.

New Mileage Ticket.—The Pennsylvania Railroad announces that the new twenty dollar 1,000 mile tickets placed on sale September 1, 1906, have become so popular that it is difficult to keep up the supply. These tickets are good for one year and for the passage of holder and any number of other persons on any of the lines of the company east of Pittsburgh and Buffalo. These tickets are particularly popular with business houses which keep a force of men on the road.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

APRIL, 1907

SOUTH LOUISVILLE SHOPS.*

LOUISVILLE AND NASHVILLE RAILROAD.

V.

SMITH SHOP.†

Location.—The blacksmith shop lies alongside the machine and erecting shop, the east end being directly opposite one end of the freight car repair shop and alongside the traveling crane. (For plan of layout see page 208, June, 1906.) Finished material is delivered by the shop crane to the traveling crane for distribution, except in such instances as it may be more convenient to truck it to the machine shop. Raw material is delivered and stored at the north side of the building. One of the material tracks enters and extends across the shop and material for the bolt shop is unloaded from the car to the rack inside of the shop. Finished material for shipment to outside points may also be loaded on cars on this track.

Building.—The blacksmith shop is a steel frame brick building 150 ft. 9 in. x 402 ft. 1 in., outside dimensions. It has a floor area of approximately 60,000 sq ft. Smith shops which serve both car and locomotive departments ordinarily have from 20,000 to 40,000 sq ft. of floor area, but at the South Louisville shops a greater space is required because of the large amount of new equipment, both car and locomotive, which is constructed. The building is divided by two rows of columns into three bays, the center one of which is 70 ft. wide, center to center of columns. The distance from the floor to the underside of the roof truss of this bay is 35 ft. 3 in., and it is served by a 10-ton Niles traveling crane. As nearly as we can find this is the first railroad blacksmith shop in this country to be equipped with a traveling crane. The cage for the crane operator is only 10 ft. from the floor, in order to keep him away from any gases which may gather near the roof. The monitor is about 35 ft. wide and is almost as long as the building. The side windows in the center bay are about 16 ft. high and extend the entire length of the building. These permit the smoke to pass out. There are no hoods or smokestacks over the forges. Two years' experience has proved that smoke hoods are not necessary, as the shop is clear of smoke and gas at all times. The sheet copper ventilators, 3 ft. in diameter, are spaced about 40 ft. apart.

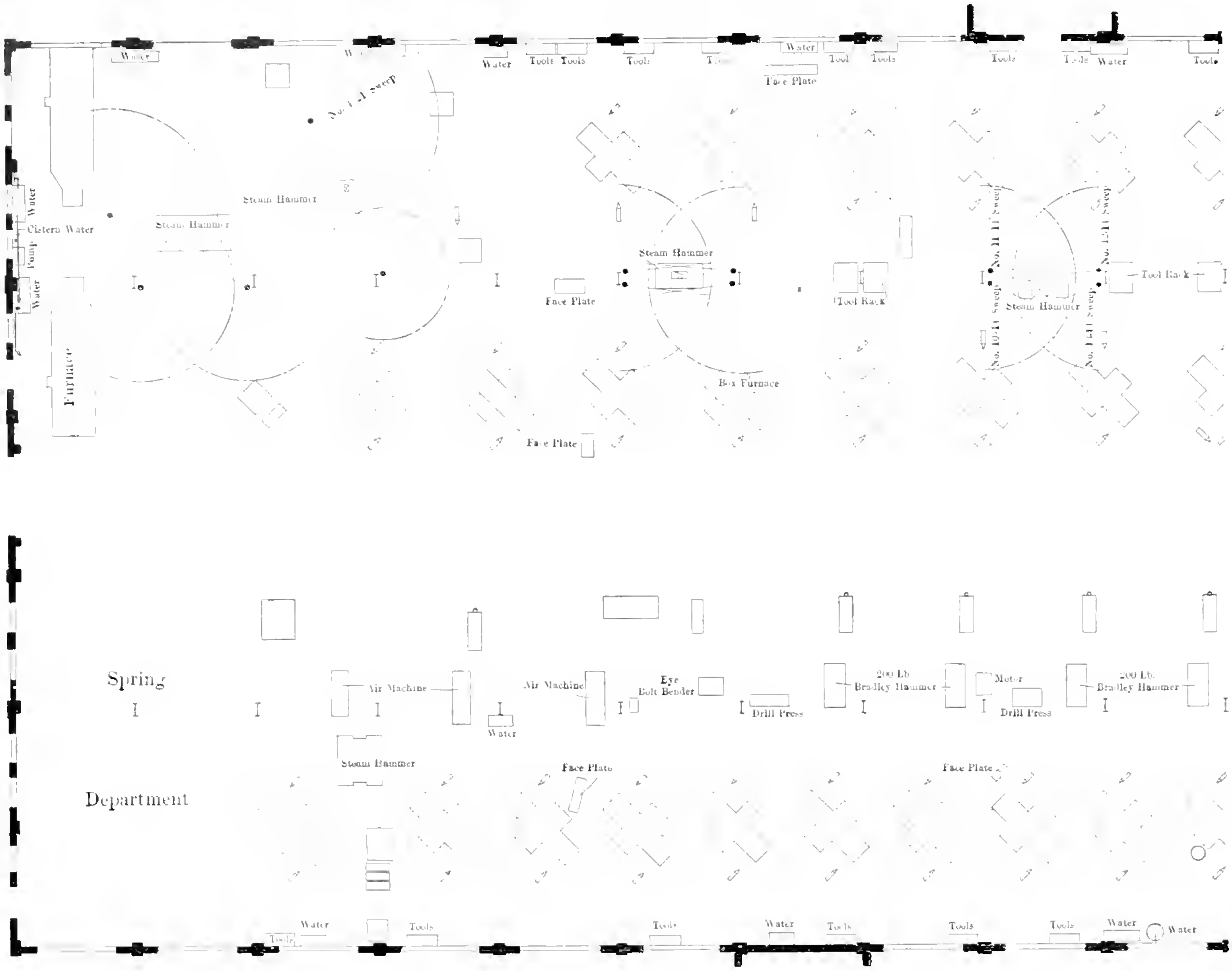
The two side bays are each about 40 ft. wide and the underside of the roof truss is 20 ft. above the floor. On the side of the building nearest the machine shop are two additions, each about 20 ft. sq., one containing the apparatus for heating and circulating hot air for heating the shop and the other the blast fans. On the other side of the building is a two-story addition about 22 x 60 ft., inside dimensions, containing wash bowls and lockers. These three additions have granitoid floors; the main shop floor is of clay.

The general construction of the building is quite clearly shown on the accompanying drawings. The concrete foundations rest on creosoted piles. The roof purlins are fastened to the trusses by 4 x 3 x 3/8-in. angle clips, which are riveted to the trusses and bolted to the purlins. The roof is covered with a composition roofing. All the windows are hung on pivoted sash, except a few of those at the ends of the building and where the diagonal braces interfere. The large amount of head

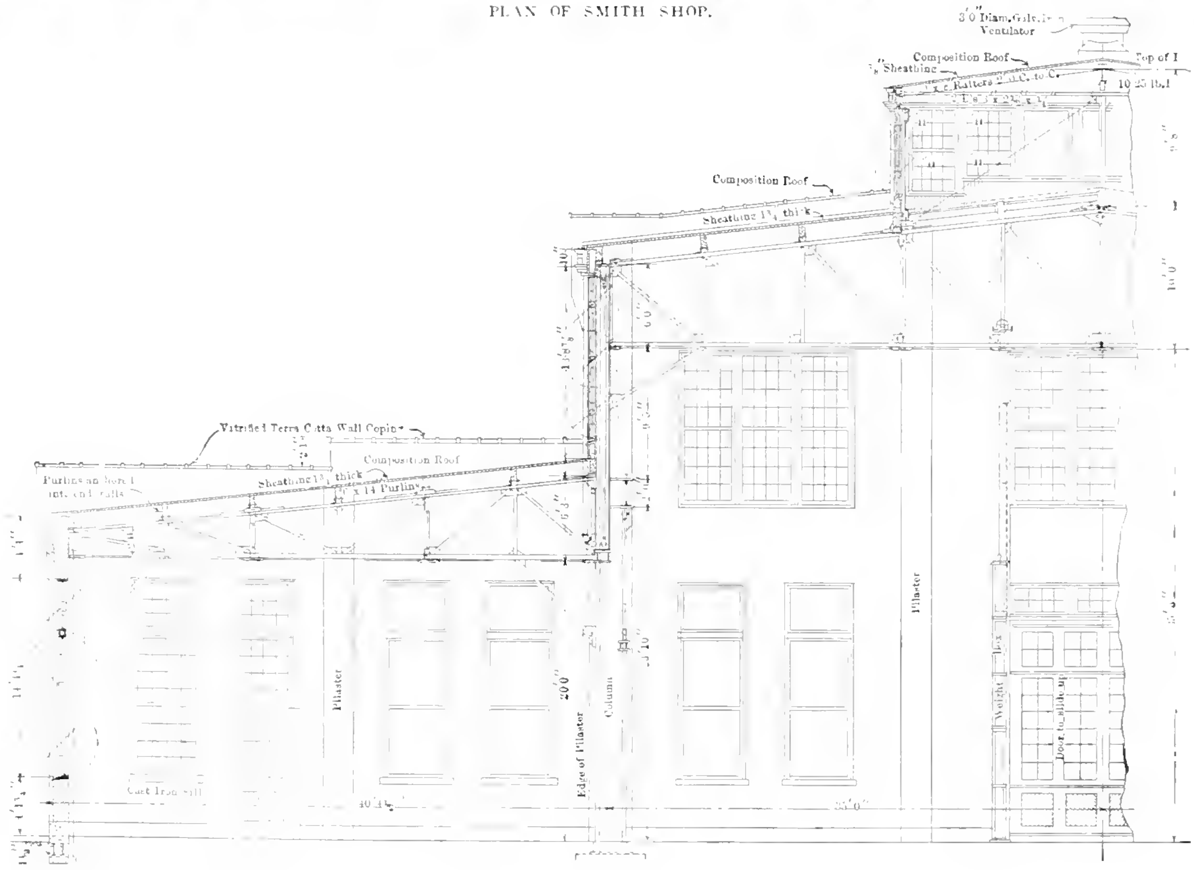
CENTRAL BAY OF SMITH SHOP.—SOUTH LOUISVILLE SHOPS.

* The previous articles in this series were: General Plan and Operation, page 209, June, 1906; Car Department, page 378, October, 1906; Power House, page 419, November, 1906; Foundry, and Pattern Shop and Storage Building, page 50, February, 1907.

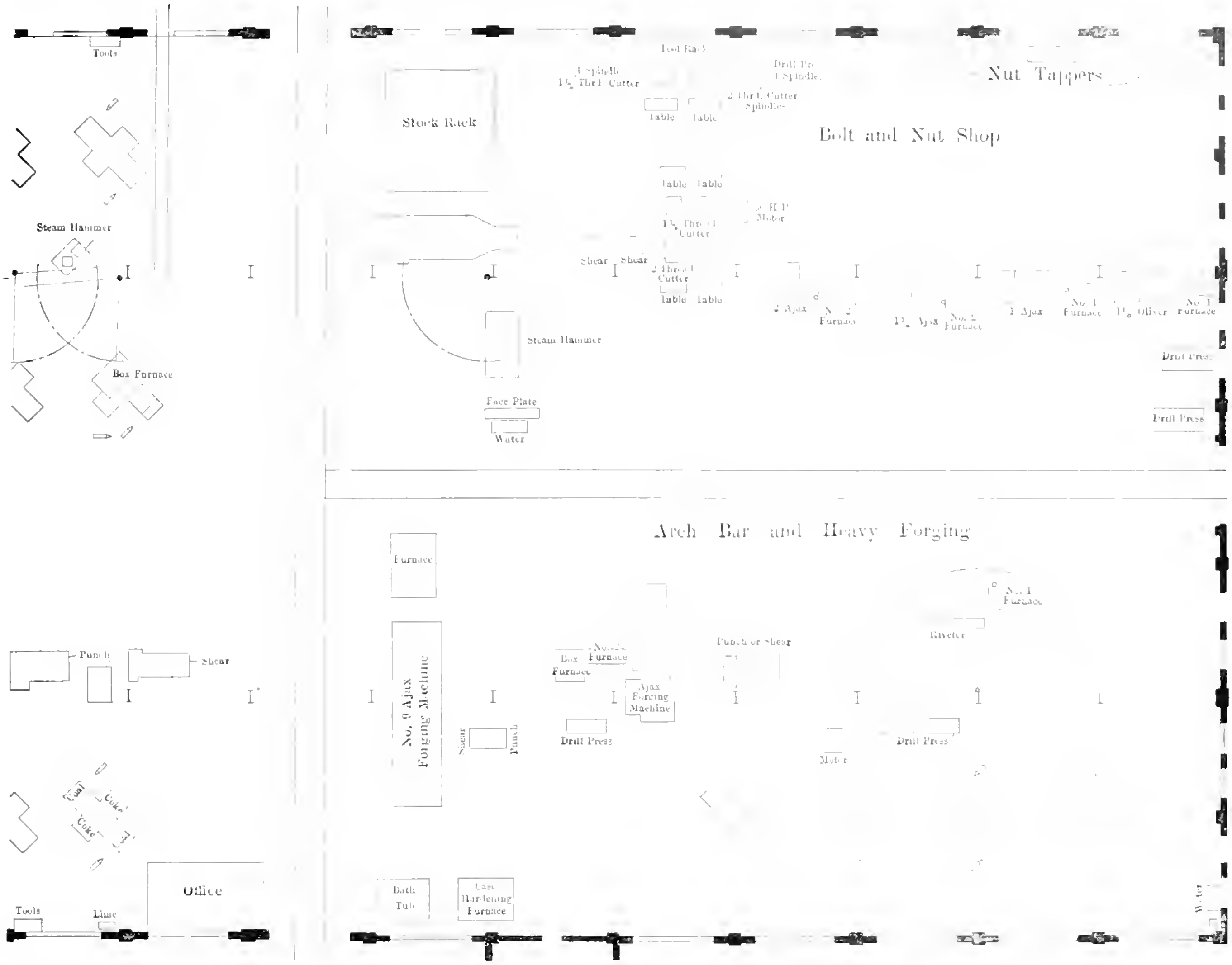
† The blacksmith shops which have recently been described in this journal are as follows: Lake Shore & Michigan Southern Ry., Collinwood, Building Construction, page 302, October, 1902; Floor Plan, page 374, December, 1902; List of Large Tools, page 42, February, 1903; Oil Furnaces and the Oil Storage and Delivery System, page 334, September, 1903. Pittsburg & Lake Erie R. R., McKee's Rocks, Building Construction, page 24, January, 1904; Equipment and Operation, page 382, October, 1904. Canadian Pacific Ry., Angus, Building Construction, page 1, January, 1905, and page 37, February, 1905; Equipment and Operation, page 363, October, 1905. Chicago, Rock Island & Pacific Ry., Moline, Building Construction, page 395, November, 1905. There was also an article by Mr. R. H. Soule on the general design and arrangement of smith shops, page 205, June, 1903.



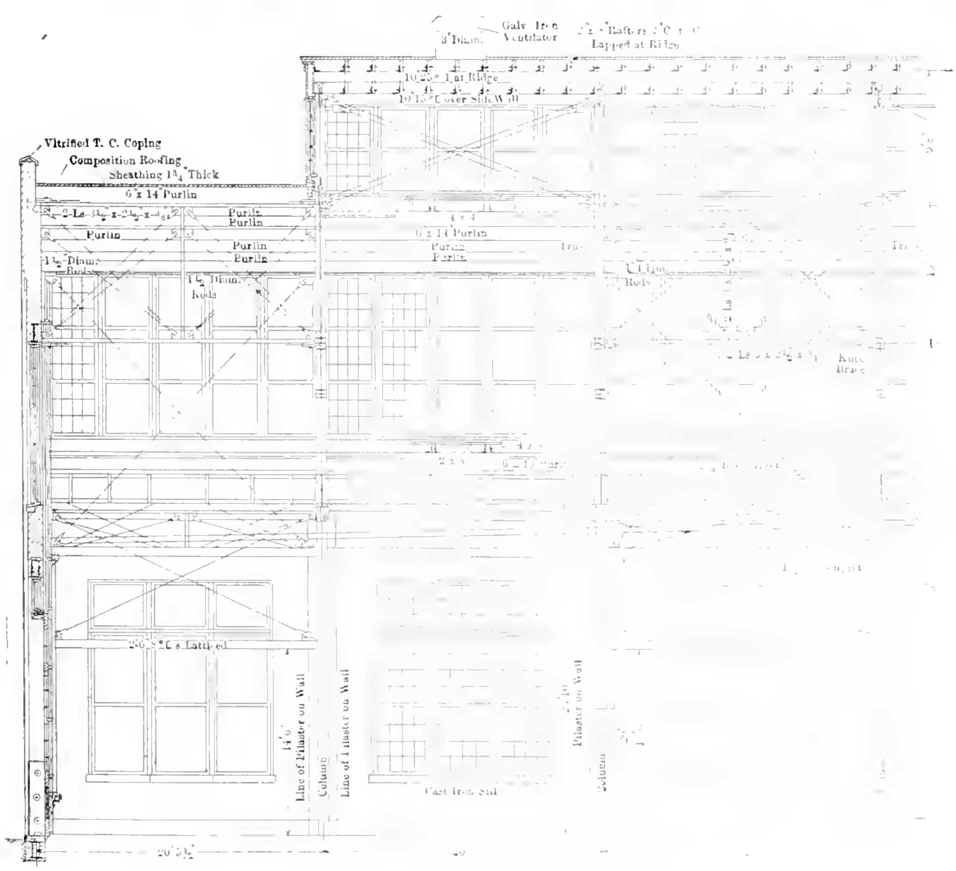
PLAN OF SMITH SHOP.



HALF CROSS-SECTION OF SMITH SHOP.



PLAN OF SMITH SHOP.

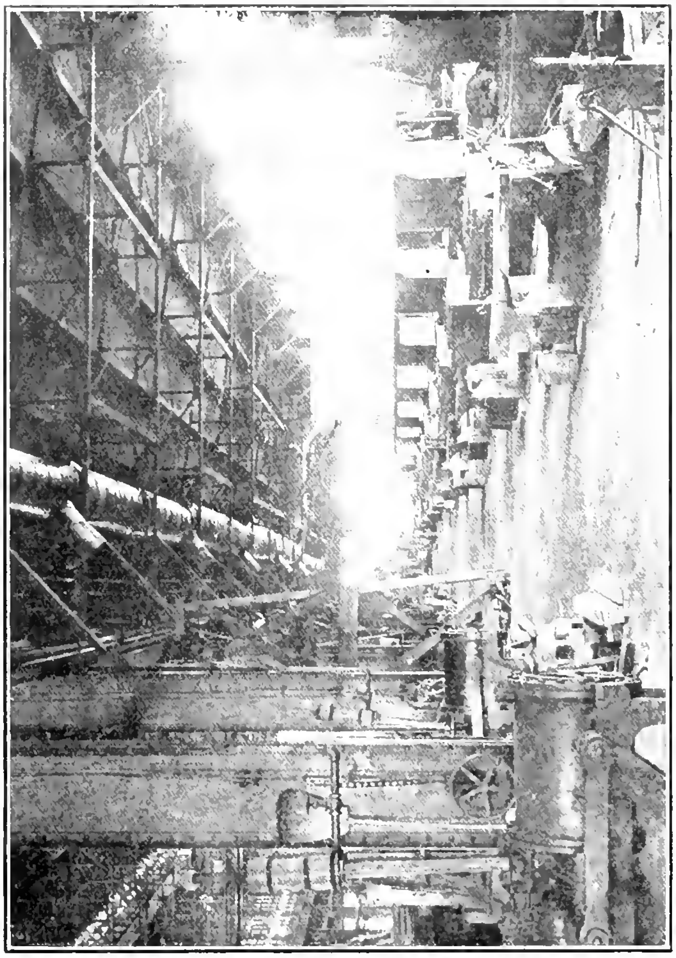


PART LONGITUDINAL SECTION OF SMITH SHOP.

room and the ventilation afforded by the ventilators and such of the windows as are usually open in the monitor and the sides of the center bay keep the shop clear from smoke and gas.

Equipment and Operation.—The two large furnaces and the two steam hammers at the northwest corner of the shop are used for locomotive frame work and heavy forging. The portion of the shop lying between these two hammers and the material track is devoted to the heavier classes of work and includes in its equipment three steam hammers. The arrangement of the jib cranes used in connection with these hammers is especially good, as may be noted by reference to the general plan. The forges in this part of the shop are spaced 20 ft. center to center. Racks for the small tools are placed along the side walls for the outside row of forges and alongside the columns for the inner row.

All material brought in from the machine and erecting shop for repairs is placed in what is known as the "bone yard" at the end of this section of the shop alongside of the materal track and the parts are not distributed to the forges until work



VIEW FROM THE SPRING DEPARTMENT.

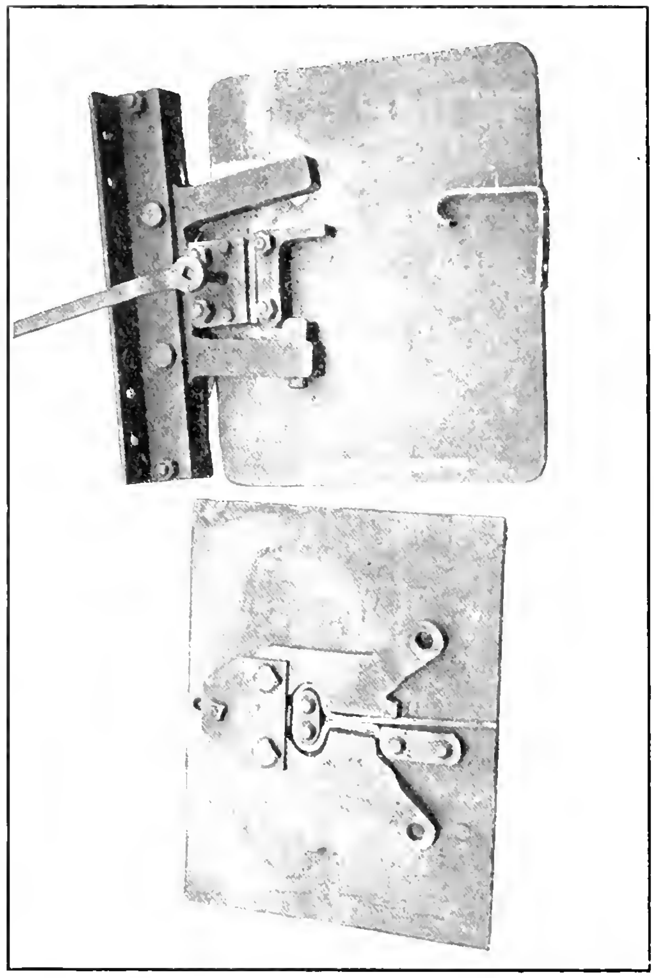
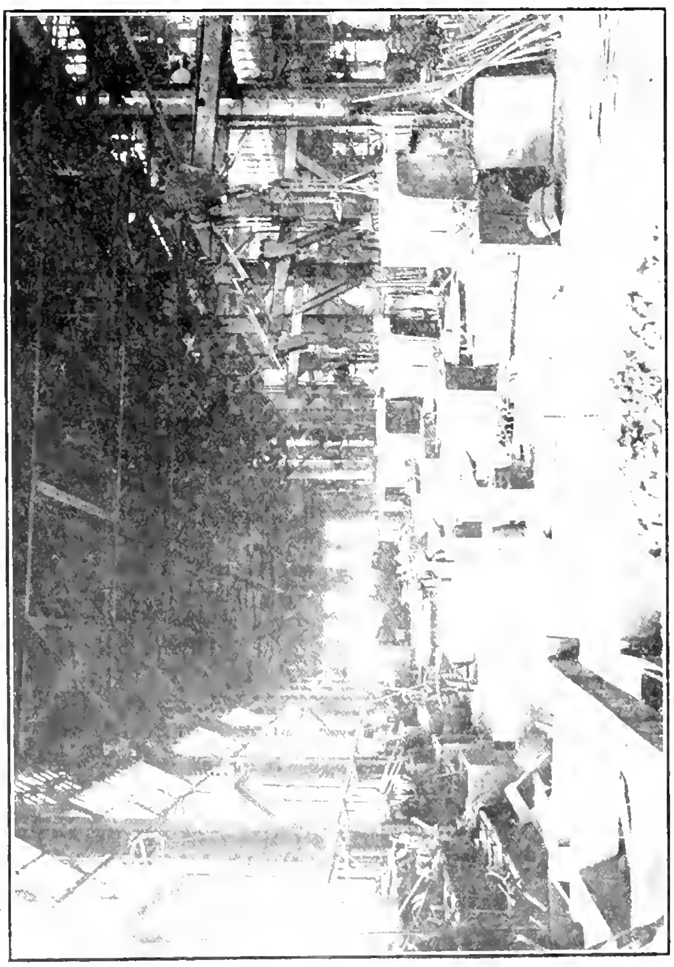
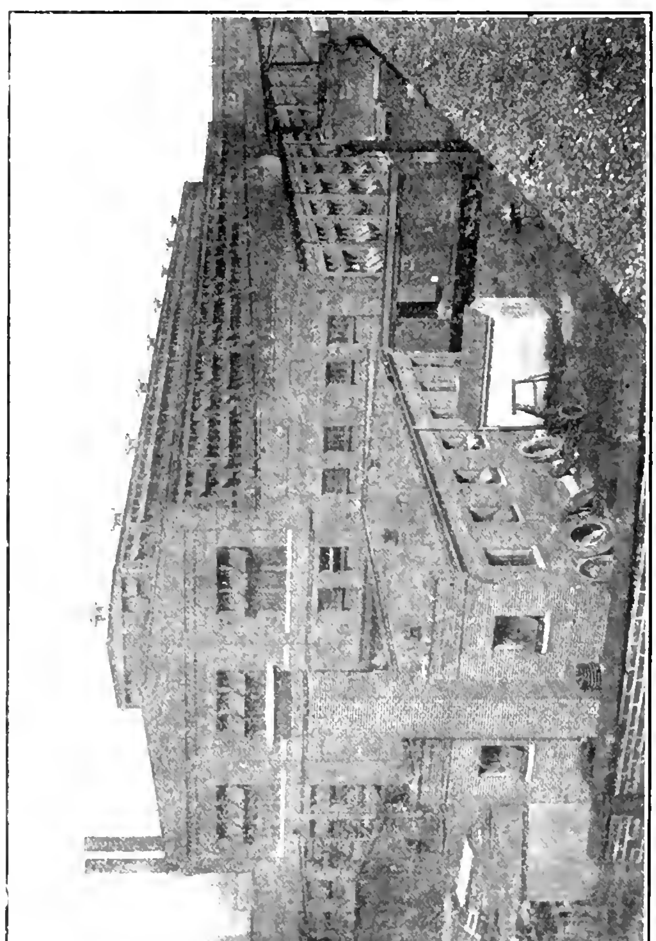


FIG. 2.—DIES USED ON BULLDOZERS.



VIEW FROM THE LARGE STEAM HAMMER.



BLACKSMITH SHOP WITH LAVATORY BUILDING IN THE FOREGROUND.

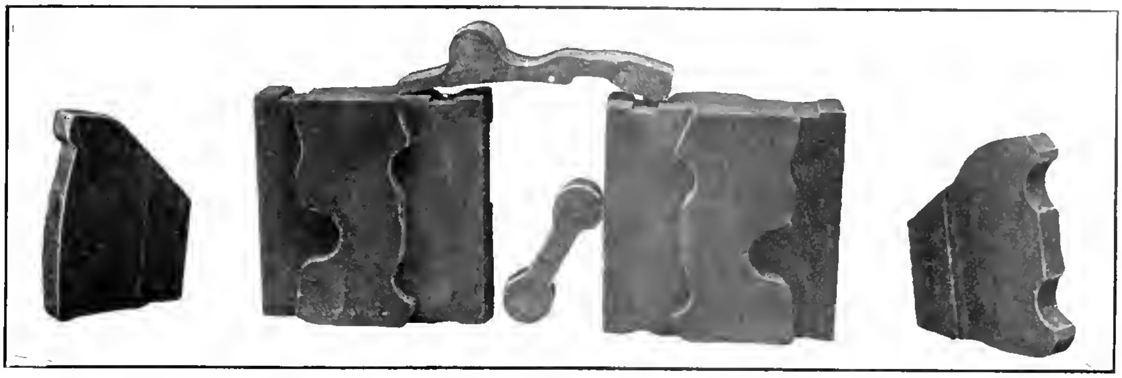


FIG. 3.—DIES AND HEADERS FOR MAKING DRIVER BRAKE AND SWING HANGERS ON THE FORGING MACHINE.

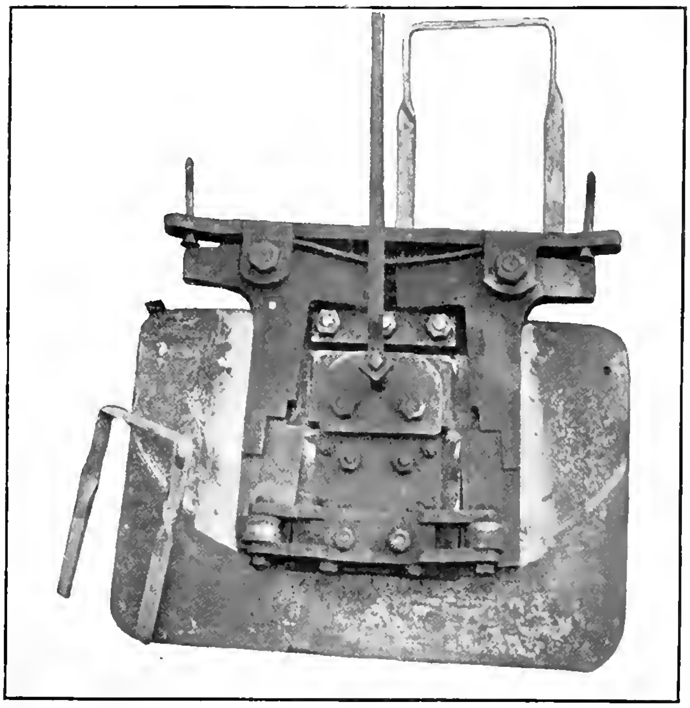


FIG. I.—DIES FOR MAKING FREIGHT CAR STEPS.

is to be commenced upon them. For this reason there is no tendency for the shop to become littered up and it at all times presents a neat appearance. In addition it enables the foreman to readily check over the repair work on hand and see that work requiring prompt attention is not neglected. The incompleted hammer work is stored in the central aisle at the end of the shop near the large hammers. The large hammer tools and the special dies and formers used in connection with the hammers, of which there are a large number, are stored in a convenient place just outside of the shop.

The spring department occupies the northeast corner of the shop. The equipment for this department has not yet been entirely installed, but it will be carefully arranged so that the various parts will progress from the rough to the finished state with a minimum amount of handling. The forges between this department and the office are used for the lighter classes of work, largely for the car department. They are spaced 16 ft. center to center.

One of the most interesting parts of the shop is that lying between this row of forges and the center of the shop. The large amount and the great variety of work which is turned out by the bulldozers, operated by compressed air, and the Bradley hammers is surprising. Since Mr. Curtis has been in charge of the motive power department he has made it a matter of policy to standardize, as far as possible, all of the cast and wrought iron parts used on the freight cars. This has not only made it possible to reduce the amount of stock carried at repair points, but also to manufacture these parts, and especially those of wrought iron, in large quantities at a correspondingly low cost. The wrought iron parts have been carefully designed with the view of manufacturing them on machines of this kind and with the least possible number of operations. A large number of dies and formers have been made for use with these machines, which when not in use are stored outside of the shop at the end.

Two or three typical devices which are used on the bulldozers are illustrated in connection with the pieces of work which are made by them. Each of these pieces is made in one operation and they can therefore be turned out practically as fast as it is possible to heat the material in the oil furnaces. The device for manufacturing the ladder steps, as shown in Fig. 1, is specially interesting. The hot iron, of the proper length, is placed in the slot between the two pieces bolted to the large plate, which when in use is nolted to the bed of the bulldozer. As the two arms which are attached to the plunger of the bulldozer move forward and come to the position shown in the photograph the iron is bent into approximately a U-shaped form. It will be noted that the two arms are in the form of bell cranks and when the block on the large plate comes in contact with the shorter arms the two long arms are forced toward each other and twist the iron into the shape shown. The two rollers guide these side arms and hold them in place.

The method of making the two pieces shown in Fig. 2 is more simple. In the first one, the two pieces which shape the iron are connected to the plunger by two arms; as the plunger moves forward the two pieces are swung around their fulcrums until they reach the position shown on the photograph. The method of making the second piece is quite similar to that of making the step, shown in Fig. 1.

This section of the shop is provided with two drill presses, placed at convenient points, and with punches and shears.

Of that part of the shop lying on the other side of the material track one portion is devoted to the manufacture of bolts and nuts, another to arch bar and heavy forging and the eight forges in the corner are used for miscellaneous work and such work as may be required by the freight car repair department, the freight car repair shop being directly opposite this end of the shop. The case hardening furnace is between these forges and the office.

The material for the bolt shop is loaded directly from the cars into the large stock rack. Two shears are placed near this rack for cutting the stock to the proper lengths. The machines for use in tapping the nuts are arranged along the side wall. The thread cutters and the Ajax forging machines for manufacturing the bolts are arranged along the line of columns, as shown on the plan.

While the equipment of bulldozers and Bradley hammers, and the devices used in connection with them, are especially complete and the work done on them is noteworthy because of the fact that the number of operations required for a particular piece of work have been reduced to a minimum, the work done on the heavy Ajax forging machines is of still greater importance. The progress which has been made in heavy forging in this shop would seem to indicate that machine forging is still in its infancy.

Generally speaking, the practice of upsetting material is avoided and the desired purpose is accomplished by reducing

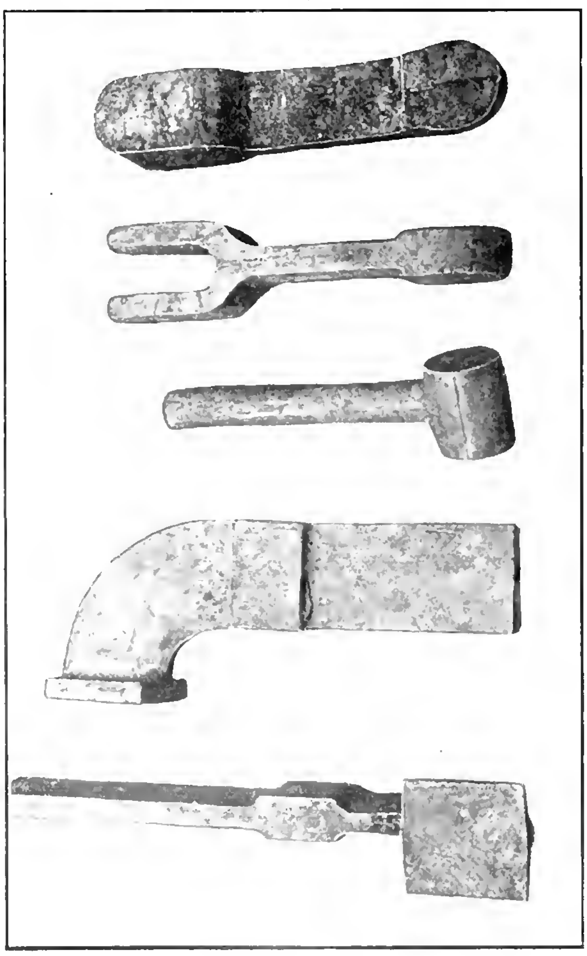


FIG. 4

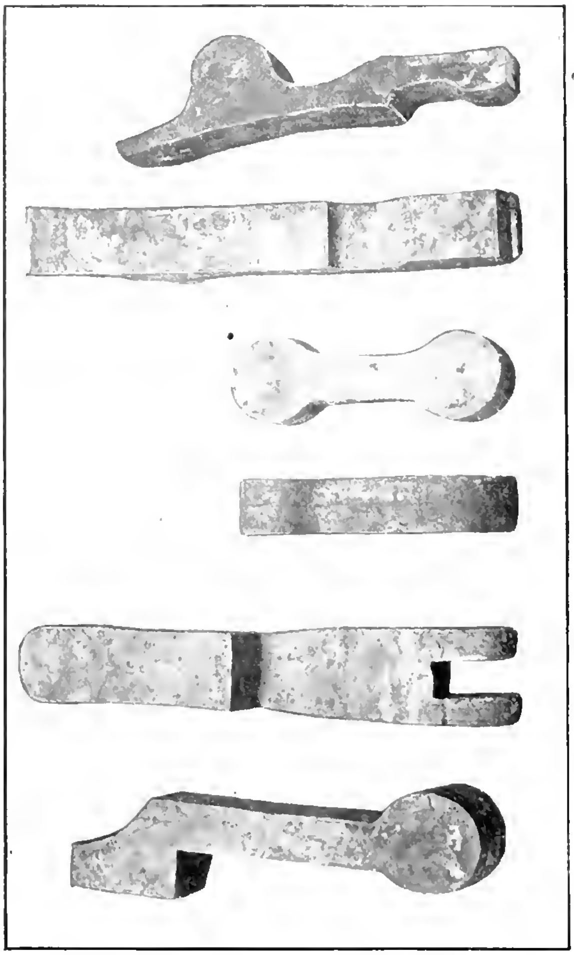


FIG. 5.

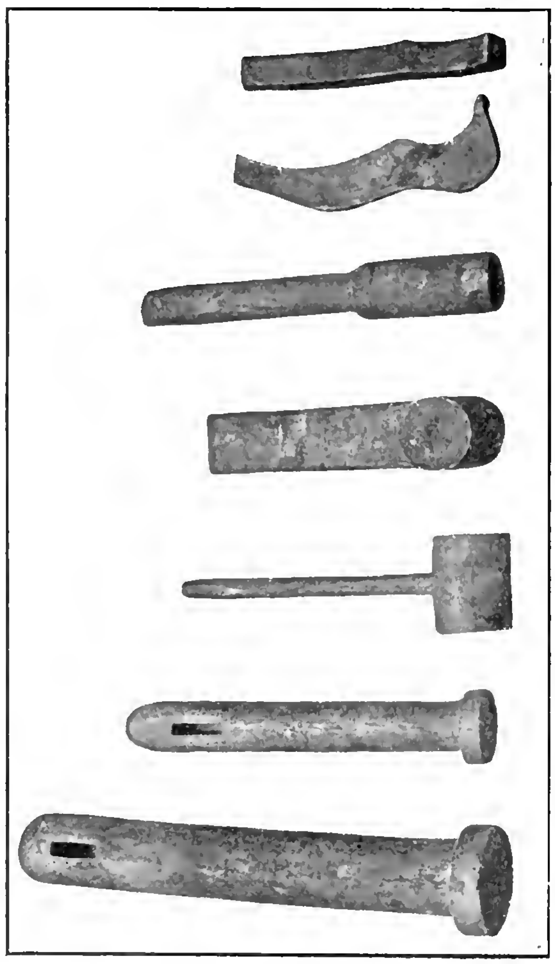


FIG. 6.

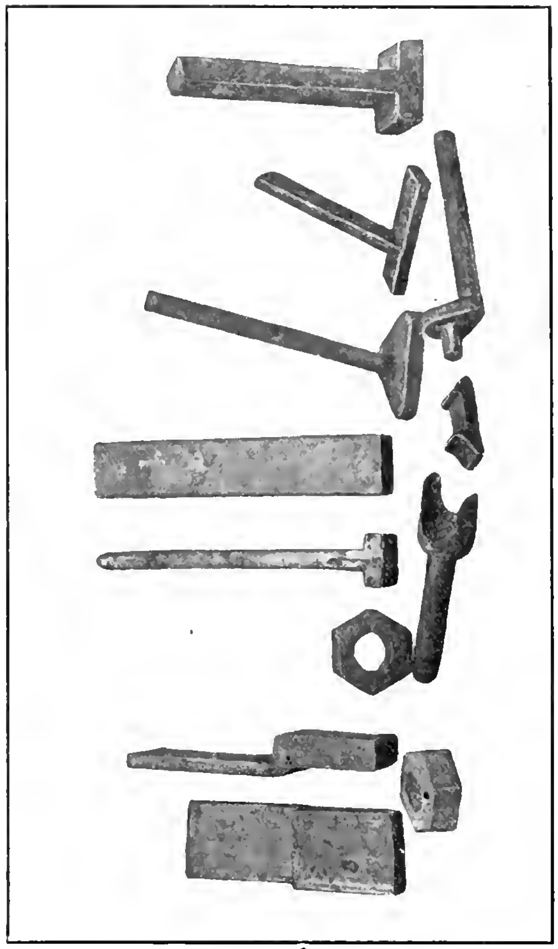


FIG. 7.

FORGINGS MADE WITH JEFFREY COMBINATION DIES ON AJAX FORGING MACHINES.

the stock or welding. Upsetting the material has a tendency to injure it while reducing it tends to refine it. All of the forgings made on these machines, shown in the accompanying illustrations, are made from bar iron which has not had any preparatory work done upon it. This result is accomplished by what is known as the Jeffrey combination dies. As an illustration, the set of dies and plungers used on an Ajax 4-in. machine for making the bottom end of a driver brake hanger and for manufacturing the swing motion hangers for engine trucks is shown in Fig. 3. The exact shape of these two parts is more clearly shown in Fig. 5. The brake hanger is shown resting on top of the dies and is made from bar iron at one stroke of the machine. The swing motion hanger, shown between the two dies, is also made from bar iron at one stroke of the machine. With the dies shown in the illustration these two pieces can be made either by reducing from bar iron or by welding, according to the choice of the operator.

With the Jeffrey combination dies it is not only possible to make the various articles with practically no preparatory work and with a minimum number of operations, but it is also possible to manufacture articles which could not otherwise be made

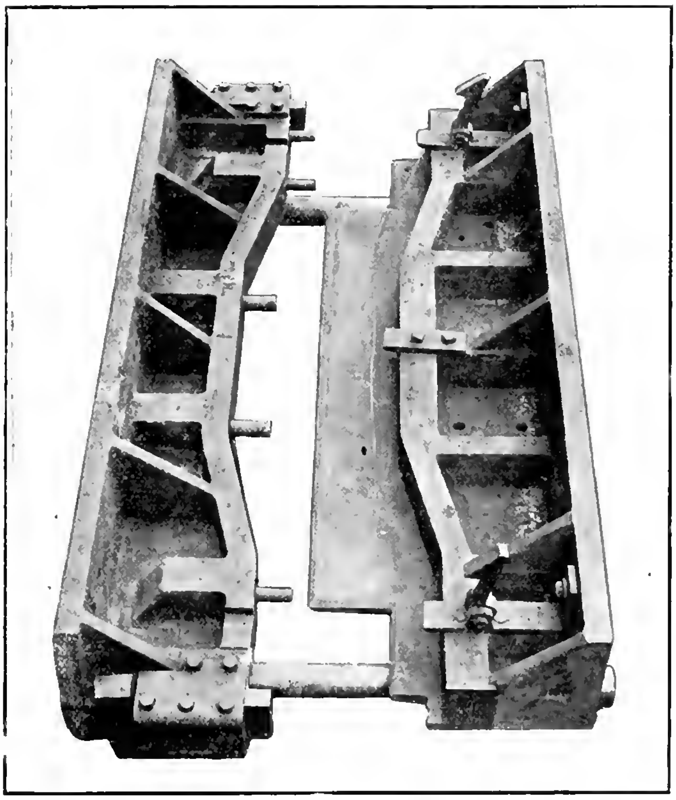


FIG. 8.—DIES FOR BENDING AND PUNCHING ARCH BARS.

on the machine. On the left of Fig. 4 is shown a cross brace which is made with three strokes of the machine. The figure in the center represents the end of a valve rod made with one stroke of the machine and the figure at the right is a swing motion hanger made with two strokes. On the left of Fig. 5 is shown an anchor which is made with two strokes of the machine. Other examples of work are shown in Figs. 6 and 7.

Fig. 8 shows the dies for bending and punching arch bars on a No. 9 Ajax forging machine. Bars of the proper length are placed in the dies and at one stroke of the machine they are finished and ready to be forwarded to the truck shop and placed on the trucks. The dies or formers are guided by the two heavy rods, one at each end. It will be noted that provision is made for bending a lug at each end of the arch bar.

Another feature that is quite noticeable in this shop is that practically all punching is done by means of templets and no time is lost in laying out. The two large drill presses at the end of the shop are used for the heavier classes of work. All the heating furnaces use fuel oil and were furnished by the Railway Materials Company.

Following is a list of the equipment in this shop.

1 6,000 lb. Steam Hammer, Chambersburg.
1 4,500 lb. Steam Hammer, Bement, Miles & Co.
1 3,500 lb. Steam Hammer, Chambersburg.
1 2,500 lb. Steam Hammer, Bement, Miles & Co.
1 1,500 lb. Steam Hammer, Bement Industrial Wks.
1 1,500 lb. Steam Hammer, Bement, Miles & Co.
1 1,000 lb. Steam Hammer, Sellers.
4 200 lb. Bradley Hammers.
1 No. 9 Ajax Forging Machine.
1 4 in. Ajax Forging Machine.
1 2 in. Ajax Forging Machine.
1 1½ in. Ajax Forging Machine
2 1 in. Ajax Forging Machines.
2 1 in. Oliver Forging Machines.
3 18 in. Compressed Air Bulldozers, L. & N. R. R.
1 10 in. Compressed Air Bulldozer, L. & N. R. R.
1 Eye Bolt Header, Williams, White & Co.
1 Combination Punch and Shear (D H.). Punch reach, 27 in.; Shear, 28 in. Bement, Miles & Son Industrial Wks.
1 No. 5 Punch, 15 in. reach, Hilles & Jones.
1 Shear and Trimmer, 24 in. reach, Sellers.
2 Round Iron Shears, Bement, Miles & Co.
3 34 in. Drill Presses, Harrington & Son.
1 36 in. Drill Press, Niles.
1 30 in. Drill Press, Putnam Machine Co.
1 30 in. Drill Press, David W. Pond Co.
1 36 in. Drill Press, Aurora Tool Wks.
1 4 Spindle Drill, W. F. & J. Barnes Co.
3 1½ in. Threading Machines, 2 Spindles, Acme.
1 2 in. Threading Machine, 2 Spindles, Acme.
1 1½ in. Threading Machine, 4 Spindles, Acme.
1 2 in. Threading Machine, 3 Spindles, Acme.
1 2 in. Nut Tapper, 6 Spindles, Acme.
1 1½ in Nut Tapper, 6 Spindles, Acme.
1 ¾ in. Nut Tapper, 2 Spindles.
1 1 in. Nut Tapper, 6 Spindles, Acme.
1 2 in. Nut Tapper, 4 Spindles.
1 ⅞ in. Nut Tapper, 6 Spindles, Bement Industrial Wks.
4 No. 1 Heating Furnaces, Railway Materials Co.
9 No. 2 Heating Furnaces, Railway Materials Co.
5 Box Furnaces, Railway Materials Co.
Case Hardening Furnace, Railway Materials Co.
Axle Furnace, Railway Materials Co.
Emery Grinder, L. & N. R. R.

In one of the additions to the building are two No. 10 and one No. 7 Sturtevant air blast fans. These are driven by two motors, a 60 h.p. and a 100 h.p. The air is conducted to the forges through three systems of underground tile conduits.

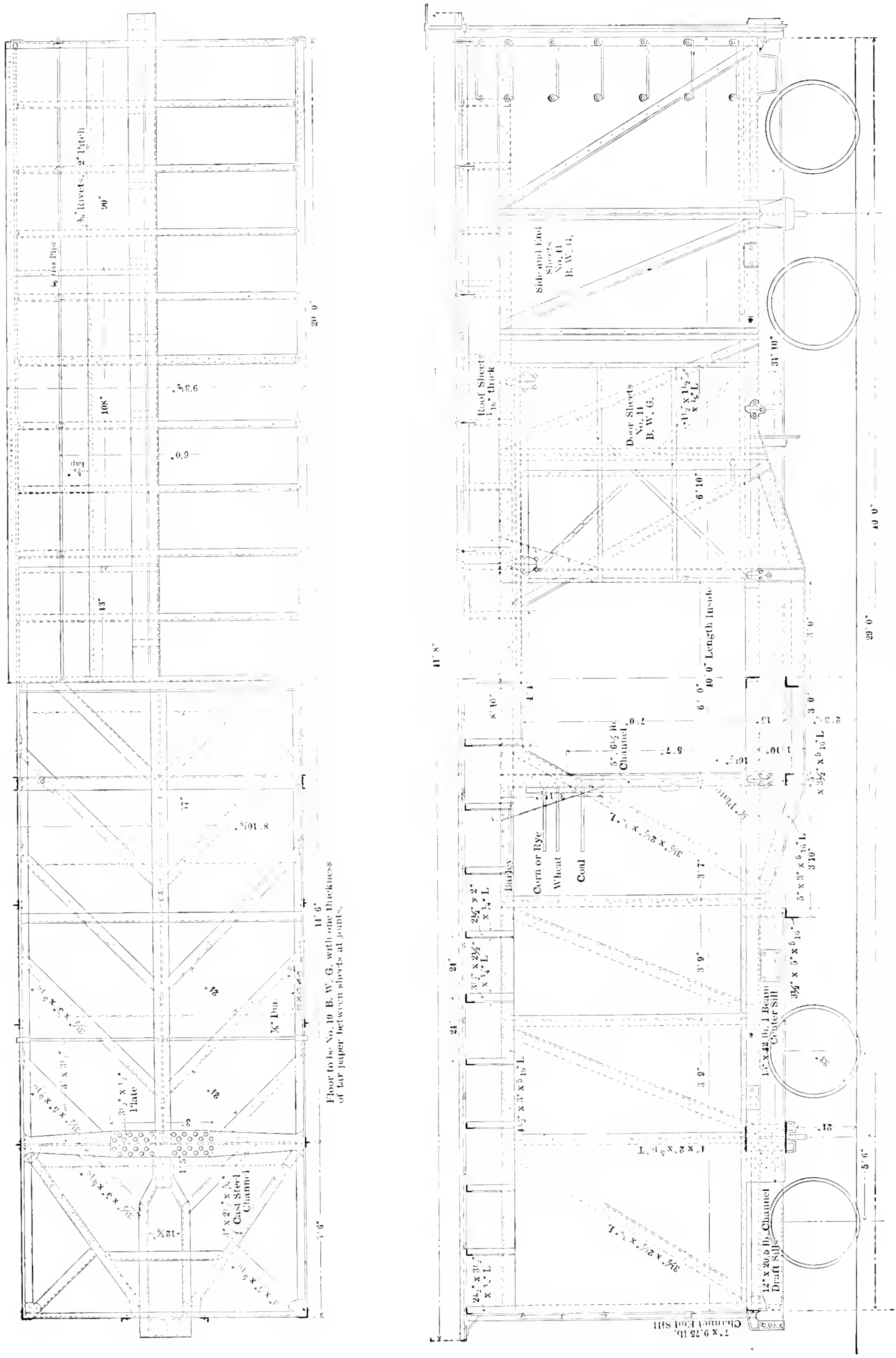
Raw material is stored north of the building and is brought into the shop over a system of larry tracks. The material is neatly arranged and is divided into sections by streets or avenues.

Steel Ties on the Pennsylvania Railroad.—A committee appointed to investigate the wreck of the 18-hour express at Mineral Point, Pa., on February 22, recommended that because of the lack of positive evidence as to the cause of the derailment and as the damages subsequent to the derailment were more serious than would have been the case with wooden ties, that the remaining steel ties be removed. The following extracts from a communication by Mr. A. C. Shand, chief engineer of the Pennsylvania Railroad, to the *Railroad Gazette*, are of interest in this connection:

"I would be greatly obliged if you would call the attention of your readers to the fact that, after most careful observation and study of the subject, I am more than ever impressed with the necessity in the near future of a substitute for wooden cross ties, and so far no material has been offered as a substitute that will meet the requirements except metal. I think, however, that all ties tested are a little lighter than they should be, and am firmly of the opinion that none of the fastenings for holding the rail in position on the tie are adequate to the requirements. When any suitable fastening shall have been designed, and there is no doubt in my mind that it will be in the near future, either by the Carnegie Steel Company or by someone else, I have not the slightest doubt that the experiments in connection with the steel ties will go forward, not only on this system, but on other leading railroads."

"What I am afraid of is that the general public, and the engineering profession in particular, will dismiss the subject of steel ties as a failure, when in reality they must come sooner or later, and the more intelligent thought given to this matter the sooner a suitable tie will be furnished which will be satisfactory in every particular."

Hard vs. Soft Boiler Scale.—It seems probable that soft, porous scale would more effectively retain against the tube surface a layer of water or vapor of low conducting power. Such facts seem to indicate that we should accept with caution the assumption that hard scale will cause a greater loss than soft scale.—*Edward C. Schmidt before the Western Railway Club.*



PLAN AND SIDE ELEVATIONS OF ALL-STEEL FORTY-FOOT BOX CAR—UNION PACIFIC RAILROAD.

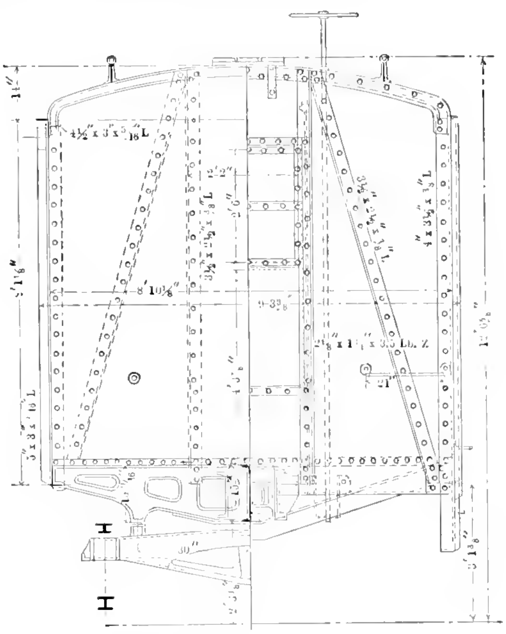
ALL-STEEL BOX CAR—UNION PACIFIC RAILROAD.

ALL STEEL BOX CAR.

UNION PACIFIC RAILROAD.

There has recently been finished at the Omaha shops of the Union Pacific Railroad two all-steel box cars which, as far as we know, are the first all-steel cars of this type ever built. These two cars are of slightly different design and have been constructed as sample cars, the service of which will be closely watched. The results obtained on the road will determine the value of the type and the features of design for future cars.

The car illustrated weighs 38,050 lbs. total. The other all-steel car weighs 38,450, and the Harriman Line standard 40-ft. wooden box car weighs 42,200 lbs. and is somewhat smaller in cubic capacity. The two steel cars have the same inside dimensions, being 40 ft. long, 8 ft. 10⅛ in. wide and 7 ft. 11 in. high, making them 4 in. wider than the standard wooden car and 1 in. less in height. The cubic capacity is 2,800 cu. ft. and the weight capacity is 100,000 lbs.



END ELEVATION—STEEL BOX CAR.

The difference in design between the two steel cars is confined to the side framing and will be pointed out in detail in a following paragraph.

The illustrations show the construction quite clearly, and from an inspection of them it will be seen that the designer in taking up a car of all steel has departed from the usual arrangement of wooden cars and has made such a distribution of metal as to obtain the proper strength and resisting qualities without excess weight, the result being that a car has been designed which, while of the same capacity, weighs 4,150 lbs. less in the car illustrated, and 3,750 less in the other all-steel design, a saving of nearly 10 per cent. of the weight of the wooden car or a saving of about 3 per cent. in the weight of the wooden car loaded to its full capacity. This means that in a 70 car train of fully loaded cars two extra cars of this design could be hauled on the same rating.

The center sill has been made of a single 15-in. 42-lb. I beam, which extends continuously between and through the bolsters, being terminated 17 in. beyond them. To the web of the projecting section are riveted two 12-in. 20½-lb. channels, which are bent outward from the connection, forming two draft sills 12⅞ in. apart, extending through and beyond the end sill. The end sill consists of a 7-in. 9¾-lb. channel cut away on its lower side for the coupler shank, and at this point is located a steel casting joining the draft sills and end sill and forming a support for the coupler. The side sill consists of a 3 x 5 x 5/16 in. angle continuous from end sill to end sill, which is reinforced below the door opening by a short girder having the side sill as its upper member and a lower member of the same sized angle bent to the proper contour to form a girder 22 in. deep in its center and between door posts, and terminating at the foot of the adjoining side posts. The web of this girder is formed by continuing the side plating below the side sill and under the door opening.

The cross bracing between the center and side sills is made up of 3½ x 4 x 5/16 in. angles set at an angle of about 45 degrees with the center line and spaced 24 in. apart. These are properly trimmed and flanged for connection to the web of the center and side sills. There are also 5 angles of the same size extending continuously below the center sills and connecting to the side sills. One of these is located below each door post, one in the center of the door opening and one connecting at the end of the side sill girder. The end frame bracing between the bolster and end sill is formed of two cast steel channels between the junctions of the draft sill and end sill and the bolster with the side sills, as well as two angles between the corners and these diagonal steel channels. There are also diagonal braces between the bolsters and the back end of the draft sills.

The superstructure or body framing consists of a 4½ x 3 x 5/16 in. angle plate, 4 x 2 x 5/16 in. tee iron posts and angle diagonal braces. In this design there is one post over the bolster and two posts between that and the door posts with diagonals between each. The corner posts are of 4 x 3½ x ⅜ in. L's and the end posts of lighter angles, there being two diagonals in the end structure, as shown in the illustration. The door posts are made up of 5-in. channels extending from the bottom member of the girder below the door opening to the side plate. The diagonal brace at this

point extends from the bottom of the adjacent post, which is the end of the side sill girder, to the side plate at a point inside the connection to the door post, and thence continuously above the door opening and down on the other side in the same manner, thus forming a truss around the door opening, with the door posts as the vertical members and the side girder as the tension member. The construction is further reinforced by ¼ in. gusset plates between the plates and the diagonals and between the door posts and side sills.

The other design of all steel car differs from the one shown by having this truss extending all the way between the bolsters. The diagonals between the vertical posts inside the bolsters are eliminated and the angle forming the upper member of the truss extends from the junction at the bolster continuously over the door opening, the part from the bolster to door posts being reinforced by a second angle of the same size. The side sill girder is also lengthened to extend between bolsters, having its deepest part between the door post in the same manner as the car shown. That arrangement makes it necessary to use one additional post between the bolster and the door and to cut the vertical posts at the junction with the diagonal, which point is then reinforced by a gusset plate. For this reason, as well as the reduction in total weight, the design shown herewith is considered to be preferable.

The carlins are formed of 3½ x 2½ x ¼ in. L's formed to the proper contour for an elliptical shaped roof and spaced 24 in. apart. They are connected to the side plates only and have no longitudinal bracing, since the roof sheets of 1/16 in. steel give all the stiffness necessary in this direction. The roof is surmounted by a wooden running board and two safety rails. The side sheathing, which is No. 11 B. W. G. steel, or practically ⅛-in. material, is inside the side framing, giving a smooth interior. The floor is of No. 10 B. W. G. steel with flanged connections, giving a perfectly smooth floor. Tar paper is placed between the sheets at the joints.

The doors are formed of steel plates and braces, as is clearly shown in the illustration. The bolsters are of cast steel in two pieces, 15 in. deep at the center and secured to the center sill by top and bottom cover plates. They were supplied by the Buckeye Steel Castings Co., Columbus, Ohio.

The trucks have the Andrews cast steel side frames, 600-lb wheels and M. C. B. standard axles, with 5½ x 10-in. journals. Sessions Type C draft gear has been applied to both steel cars.

STEEL PULLMAN SLEEPING CAR.

The Pullman Company has recently completed an all steel sleeping car, which, in arrangement and size, conforms to the present standard twelve section car. It is being placed on private exhibition at a number of the larger terminals throughout the country and is run on short trips out of these terminals with parties of guests aboard. The car is named Jamestown, and it is expected that it will be placed on exhibition at the Jamestown Exposition during the coming summer.

The framing of the car throughout is of steel and practically all of the finishing is steel, aluminum, brass or fire proofed composite board. The underframe consists of two 15 in. I-beams with a ½ in. cover plate on top only, which extend continuous through the body end sills. Each center sill is trussed with a 2 in. truss rod, with the saddle on the bolster and posts on the two center cross bearers, the ends being anchored to the body end sills. The bolsters are of the double type and are in a steel casting integral with the body end sill and the platform beams, draft sills, centre plate and bridge and side bearings. This is a very large casting and combines within itself practically all of the end of the underframe. It was furnished by the Commonwealth Steel Co. The platform end sills are also steel castings and are riveted to the platform casting. The cross bearers are 4 in number equally spaced between the body bolsters and are of cast steel in one piece. They extend under the centre sills and are of the open or truss type. Floor beams are located between each cross bearer and also between the cross bearer and the bolster, and are 4 in. channels laid with the web horizontal. They are fastened between the centre and side sills. The side sills, which form the lower members of the side girders, are 6 x 6 x ½ in. angles continuous between end sills. The web of the side girder is a ¼ in. plate about 30 in. deep and forms the side sheathing of the car below the windows. The upper member of the girder is a 3 in. steel bar on the outside of the side posts, which are offset around it. All the rivets in the side sheathing are counter sunk and filed to a smooth finish, giving the car an exceedingly good appearance.

The side posts consist of 4 in. I-beams, two in number for each wide pier and single beams for narrow piers. These posts are continuous from the side sill to the deck sills, the upper part forming the carline for the side deck. They are offset at the bottom, belt rail, plate and other points where necessary to clear continuous members. Wherever possible the webs of these posts are punched full of holes for reducing weight and giving a passage for electric wires, etc. The pier covers are 1/16 in. steel plate and are put on with counter sunk rivets. The deck sill consists of a T-iron extending continuous between the body end plates and is secured to the ends of the side posts, which form the carlins of the side roof. The carlins in the upper deck are 1/16 in. pressed steel of channel section and formed to the proper contour. These carlins also form the deck posts at the double piers but at the narrow piers the deck posts are flat bars. The purlins are of 1/16 in. steel pressed in channel shape. The roof is of galvanized iron with copper flashing.

The end frame construction consists of 2 posts of 4 in. I-beam section located under the deck sills and secured to them and to the body corner post at this point. At the bottom they are secured to a 4 x 4 in. angle, which is riveted to the body end sill casting.

The floor construction is double, the deadening floor being placed on top of the cross bearers and floor beams and above this is supported the floor of the car formed of Monolith cement laid on corrugated iron of Keystone section. Between these two floors is placed the deadening material. Two thicknesses of asbestos board are placed in the sides and ends of the car between the sheathings and extending from the side sill to the side plate for reducing noise and as insulation.

The interior finish consists of pressed steel seat frames with the usual plush seats; pressed steel upper berths and attachments as far as possible. The interior is finished in a light gray shade with suitable decorations and striping and gives a very light, clean appearing interior. The fittings are of the usual Pullman standard. The trucks are of the six wheel type having cast steel frames and bolsters. This car throughout has a most satisfactory appearance and is claimed to be a very quiet, easy riding sleeping car.

COURSES IN RAILWAY ENGINEERING.—The University of Illinois is issuing a small leaflet giving general information about the courses offered in the School of Railway Engineering Administration, which has recently been established. These courses are exceedingly practical and furnish facilities for the proper equipment of high class men for any department of railroads. The University is possessed of an excellent dynamometer car for steam railroad usage; a high class electrical railway test car; as well as very complete laboratories and shops. The instructing staff has been very carefully selected for this special work and promises to make the school one of the best of its kind in the country.

INCREASE IN ROLLING STOCK IN TEN YEARS.—The following table is given in a report recently made by Mr. Slason Thompson to the General Managers' Association of Chicago:—

	1906.	1896.	Increase in 10 years, per cent.
Locomotives:			
Number	51,357	35,950	42.8
Weight (tons)	3,286,848	1,797,500	82.8
Average weight (tons)	64	50	28.0
Freight cars:			
Number	1,851,409	1,221,887	51.5
Capacity (tons)	58,155,088	29,936,231	95.3
Average (tons)	32	24.5	30.6

DISPATCHING BOARD FOR ENGINE REPAIRS.

BY C. J. MORRISON.*

A train dispatcher does not direct the movements of trains, assign meeting points and keep everything moving with nothing but his memory to guide him. He has a board which shows at a glance the position of each train. Reports come in from each station as the trains arrive and depart. In addition he is furnished with information concerning the tonnage of each train and the condition of the engine and is thus able to predict its speed over each portion of the division.

Usually the general foreman is the dispatcher in the locomotive repair shop. In most shops he is expected, without a board and without reports, to dispatch the engines through the shop and keep each up to its schedule. Fortunately mistakes on his part are not as serious as those made by the train dispatcher. Nevertheless, they cost time and money. The average general foreman is asked to carry far more in his head than the train dispatcher would have to carry had he no boards or reports. In a shop which usually holds twenty-five engines and has thirty gangs, the number of possible combinations of the work is so great that it would startle the general foreman to see it printed. Yet, only one combination will produce the best result.

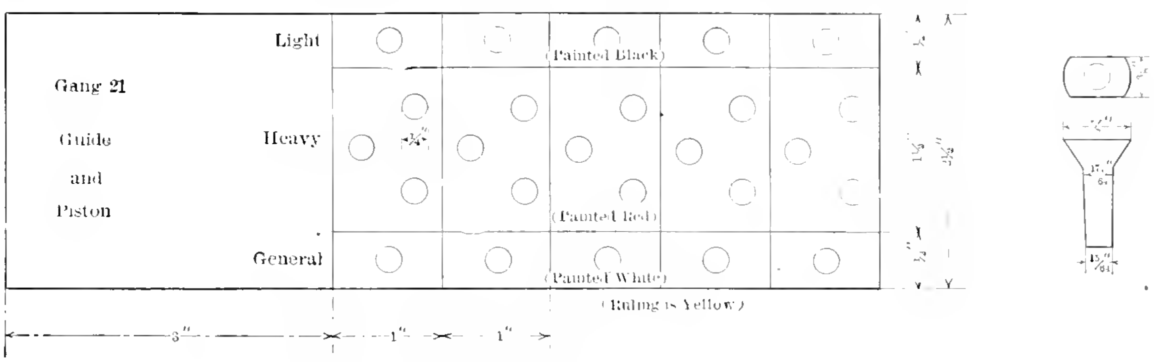
In the Topeka shops of the Santa Fe, in addition to the schedules and reports described in the December, 1906, issue of the AMERICAN ENGINEER, a board has been devised to aid the general foreman, and, as a side issue, the gang foreman. This board shows at a glance the condition of the work on each engine, shows what has been done, what remains to be done, and what is behind schedule. The board is checked up during the day by a time-keeper, so that it is always up to date. It is not necessary for the general foreman to waste his time and energy running up and down the shop to ask first one, then another foreman if his work is done. He can glance at the board and direct his foremen over the telephone.

The board is 5 ft. high and 6 ft. wide, and is ruled in thirty horizontal sections, part of one of which is shown in the sketch. The vertical sections represent the days of the month and are numbered from one to sixty-one, so as to carry two months. A bar of iron 1/8 x 1 in. carried on two horizontal rods of 1/4-in. round iron, one at the top and one at the bottom of the board, marks the day. Pegs, as shown in the sketch, with white, green, yellow and pink pasters show the engine numbers. When an engine enters the shop, pegs are made for the work of each gang and placed on the board, on the dates the work is due, in the light, heavy or general repair column according to the class of repairs. Pegs are made for each job, as shown in the general schedule on page 338 of the September, 1906, issue of the AMERICAN ENGINEER. As an example, consider the guide and piston gang. The colors signify as follows:

White.................................Crossheads Ready
Green.................................Guides Up
Yellow.................................Pistons Ready
Pink.................................Pistons in Engine

When a heavy repair engine enters the shop the white peg will be placed on the date corresponding to the 8th day, the green peg on the 9th, the yellow peg on the 12th, and the pink on the 13th. When the work is completed the pegs are placed in spaces at the right of the board until the engine leaves the shop, when they are removed. As the rod marking the day advances all the pegs back of it represent the work behind schedule, while the pegs in front of it represent work due on that and future dates.

If a gang falls behind in some work that will delay another gang, the peg for the second gang will be advanced to the date when they will be able to proceed. Such a falling behind of one gang may congest the work of another gang at a future date. This is at once shown by the pegs and is provided for in advance. The foremen are furnished every morning with reports which not only show the work that is behind schedule, but the work that is due that day, and, in the cases of some gangs, the work that is due the following day. With such a system as this, there is little excuse for work falling behind schedule, and when work does fall behind, the board shows at a glance which gang is causing the delay.



SKETCH OF A SMALL SECTION OF THE DISPATCHING BOARD IN THE ERECTING SHOP.

When a scheme of this kind is advanced the question is always asked—"What addition to the clerical force is necessary?" The reply is—"None." The regular time-keepers move the pegs and the office boy finds time to put the pasters on them. The money saving effected is rather difficult to estimate, as it depends entirely upon the delays eliminated and the value per day of the locomotive.

* General Erecting Foreman, Topeka Shops, Atchison, Topeka & Santa Fe Railway.

LOSS OF HEAT DUE TO BOILER SCALE.—In so far as generalization is warranted we may sum up the results of the tests in the following conclusions:

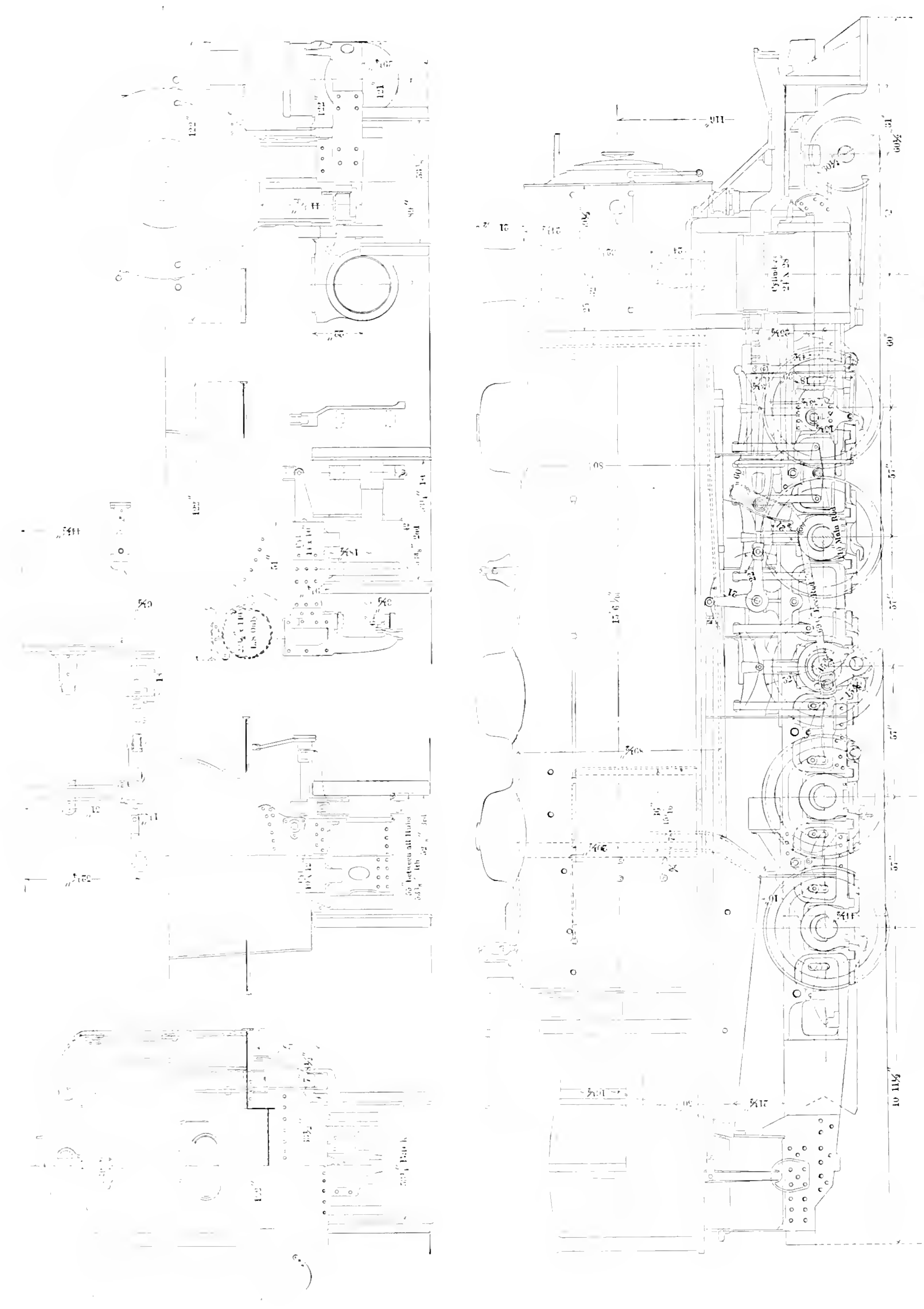
1. Considering scale of ordinary thickness—say of thicknesses varying up to 1/8-inch—the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent.

2. That the loss increases somewhat with the thickness of the scale.

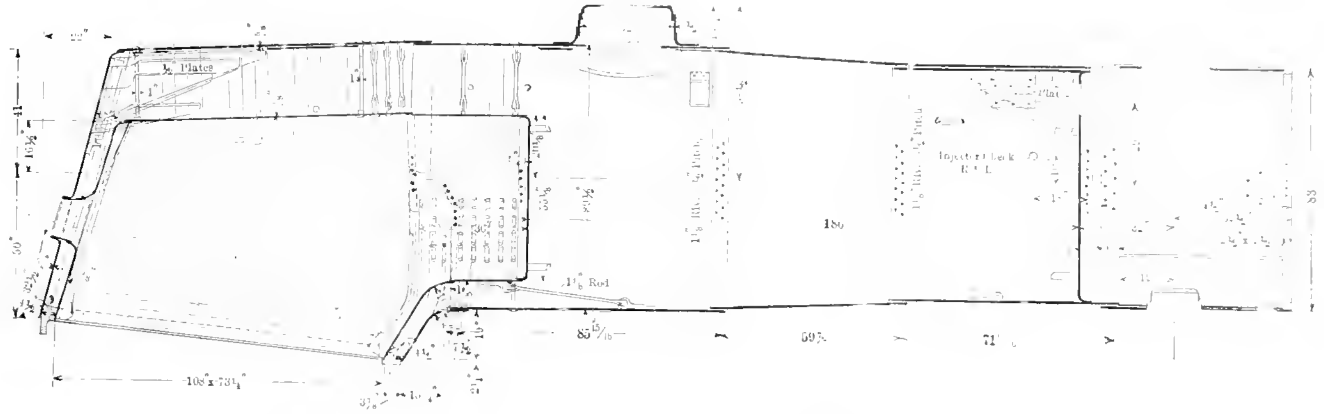
3. That the mechanical structure of the scale is of as much or more importance than the thickness, in producing this loss.

4. That chemical composition, except in so far as it affects the structure of the scale, has no direct influence on its heat transmitting qualities.—*Edward C. Schmidt before the Western Railway Club.*

AN ANTIQUATED ARGUMENT.—The New York *Sun* publishes this argument which was used in the '30s to prove that canals were superior to railroads for military purposes: "Imagine a regiment of troops with baggage, provisions, ammunition, and camp equipage transported by railroad! By canal this can be done, and the soldiers live, and cook comfortably, on the way." So, too, "canal boats will carry artillery, which cannot be transported by rail unless the guns are dismounted and the caissons taken apart." Finally, "snow will render a three hundred mile railroad impassable for weeks, and rain will wash earth over the rails in quantities which in deep cuts weeks might be needed to remove."—*Railway World.*



GENERAL ELEVATION AND SECTIONS OF SIMPLE DECAPOD LOCOMOTIVE—BUFFALO, ROCHESTER AND PITTSBURG RAILROAD.



SIMPLE DECAPOD LOCOMOTIVE

BUFFALO, ROCHESTER & PITTSBURG R. R.

The American Locomotive Company is building six decapod or 2-10-0 type locomotives at its Brooks Works for the Buffalo, Rochester and Pittsburg Railroad. These engines are intended for pushing service and are the heaviest simple locomotives ever built by that company. As is shown in the table below, they are exceeded in weight and power by but one other simple locomotive on our records.

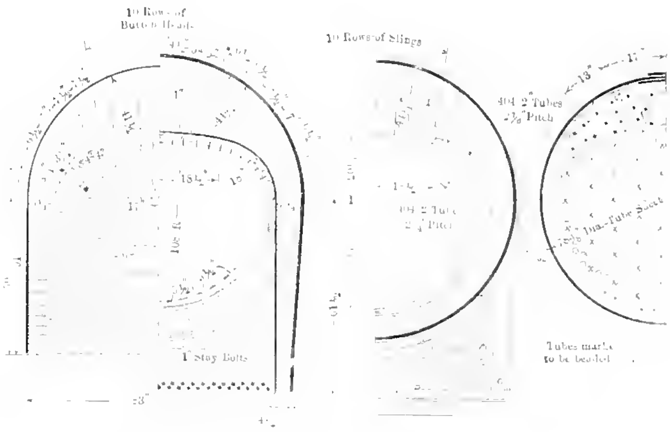
They have 24 x 28-in. cylinders, 52-in. drivers and carry a steam pressure of 210 pounds. This gives a theoretical tractive effort of 55,350 pounds, giving an adhesive ratio of 4.48. The steam is distributed by outside admission slide valves driven by the Walschaert type of valve gear. The valve gear link is supported by a special shaped casting secured to the back of the guide yoke and the reverse shaft is carried in bearings bolted to the top of a cast steel cross tie located between the second and third pair of driving-wheels. This permits of the direct connection of the reverse shaft arm with the radius bar. Reference to the illustration of the side elevation will show the advantage taken of the opportunity afforded by the use of this type of valve gear for the introduction of strong bracing between the frames and the frames and boiler.

One of the interesting features of this design is the use of a combustion chamber in the boiler. The results in the way of a reduction in boiler troubles obtained by the use of the combustion chamber on the Northern Pacific Ry. have been most satis-

Type	2-10-2	2-10-0	2-10-0	2-8-2	2-8-0
Owner	P. S. & N.	B. R. & P.	A. T. & S. F.	N. P.	D. & H.
Builder	Bald	Amer.	Bald	Amer.	Amer.
Total weight	288,000	275,000	266,500	261,000	246,500
Weight on drivers	235,000	248,000	237,000	205,000	217,500
Tractive effort	60,000	55,350	62,500	46,630	49,690
Cylinders	28x32	24x28	19 & 32x32	24x30	23x30
Diameter drivers	57	52	57	63	57
Steam pressure	160	210	210	200	210
Combustion chamber or superheater	Sup'r.	C. C.	No.	C. C.	No.
Total heating surface	4796	3535.5	5390	3437	4045.5
B. D. factor	715	815	660	835	700
Equated heating surface	1235	1085.5	1419.2	1030	1309.5
Driving wheel base	19'-9"	19'	20'-4"	16'-6"	17'
Total engine wheel base	35'-11"	28'-4"	29'-10"	34'-9"	25'-11"

factory, and the introduction of the combustion chamber in these engines shows evidence of an increasing belief in its advantages for wide firebox engines burning soft coal. The advantages claimed are, that it removes the tubes from the hottest part of the fire, thereby decreasing flue leakage; adds to the heating surface of the firebox; and gives a largely increased firebox volume which tends towards better combustion. In these engines the combustion chamber is 3 feet long and is stayed to the shell of the boiler by radial and sling stays on the upper section and by radial stays on the sides and bottom, bracing rods being also attached to the bottom and extending forward to the waist to add stiffness. Ample clearance between the combustion chamber and the shell of the boiler is provided to furnish good water circulation.

The boiler is of the conical wagon top type 80 inches in diameter at the front and has a total heating surface of 3,535.5 square



SECTIONS OF BOILER—B., R. & P. DECAPOD LOCOMOTIVE.

feet, of which the tubes contribute 3,280 square feet and the firebox the remainder. The tubes are 2 inches in diameter and 15 feet 6 1/16 inches long, there being 404 in the barrel of the boiler. The introduction of the combustion chamber, of course, reduces the amount of tube heating surface; but the experience of the Northern Pacific Railway indicates that the increase in firebox heating surface more than offsets this loss, it being found that engines with combustion chamber and less actual heating surface steam fully as well as those without combustion chamber and more heating surface.

The accompanying table will permit comparison between these and other recent large locomotives of several types. In considering this table it should be noted that the Northern Pacific 2-8-2 type is also fitted with a combustion chamber.

Other interesting details of these locomotives will be considered in our next issue. The general weights, dimensions and ratios are as follows:

GENERAL DATA.

Gauge .... 4 ft. 8½ in.
Service .... Freight
Fuel .... Bit. coal
Tractive Effort .... 55,350 lbs.
Weight in working order .... 275,000 lbs.
Weight on drivers .... 248,000 lbs.
Weight of engine and tender in working order .... 437,000 lbs.
Wheel base, driving .... 19 ft.
Wheel base, total .... 28 ft. 4 in.
Wheel base, engine and tender .... 65 ft. 3½ in.

RATIOS.

Weight on drivers ÷ tractive effort 4.48
Total weight ÷ tractive effort 4.96
Tractive effort × diam. drivers ÷ heating surface 815
Total heating surface ÷ grate area 63.6
Firebox heating surface ÷ total heating surface, per cent. 7.25
Weight on drivers ÷ total heating surface 70.3
Total weight ÷ total heating surface 77.5
Volume both cylinders .... 14.7 cu. ft.
Total heating surface ÷ vol. cylinders 241.5
Grate area ÷ vol. cylinders 3.8

CYLINDERS.

Kind .... Simple
Diameter and stroke .... 24 x 28 in.

VALVES.

Kind .... Slide
Greatest travel .... 6¼ in.
Outside lap .... 1 in.
Inside clearance .... 0 in.
Lead in full gear .... 3/16 in.

WHEELS.

Driving, diameter over tires .... 52 in.
Driving, thickness of tires .... 4 in.
Driving journals, main, diameter and length .... 10½ x 13 in.

Driving journals, others, diameter and length	10 x 13 in.
Engine truck wheels, diameter	30½ in.
Engine truck, journals	6½ x 12 in.
BOILER	
Style	Conical
Working pressure	210 lbs.
Outside diameter of first ring	80 in.
Firebox, length and width	108 x 73¼ in.
Firebox plates, thickness	⅜ and ⅝ in.
Firebox, water space	4½ in.
Tubes, number and outside diameter	404-2 in.
Tubes, length	15 ft. 6 1-16 in.
Heating surface, tubes	3,280 sq. ft.
Heating surface, firebox	255.5 sq. ft.
Heating surface, total	3,535.5 sq. ft.
Grate area	55.5 sq. ft.
Smokestack, diameter	20 in.
Smokestack, height above rail	14 ft. 11 in.
Center of boiler above rail	116 in.
TENDER.	
Tank	Waterbottom
Frame	13 in. channels
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	9,000 gals.
Coal capacity	14 tons

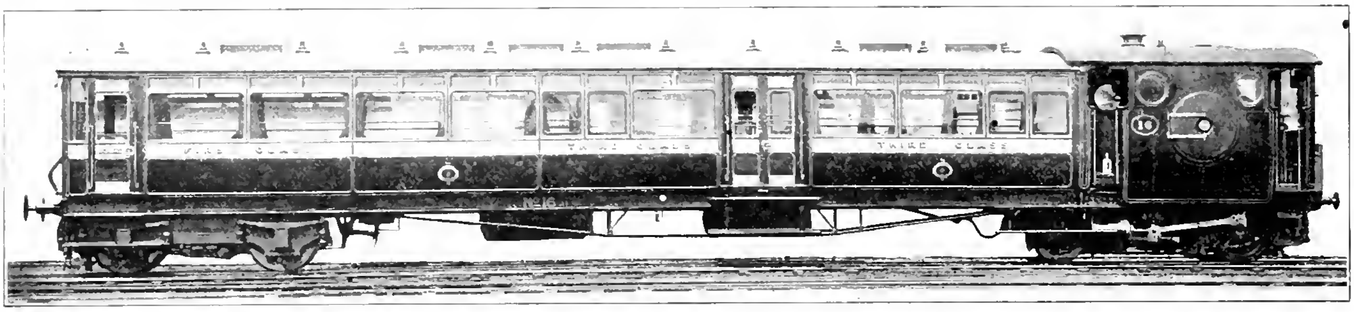


FIG. 1.—STEAM MOTOR CAR, TAFF VALE RAILWAY.

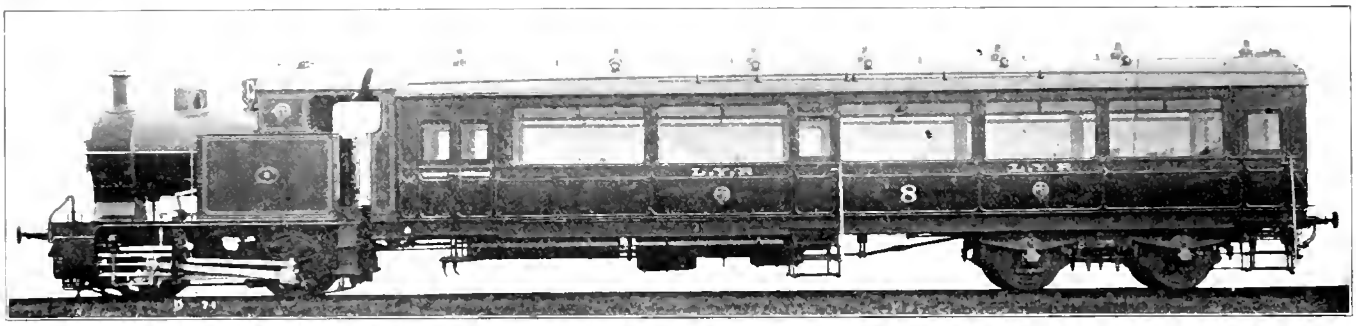


FIG. 3.—STEAM MOTOR CAR, LANCASHIRE AND YORKSHIRE RAILWAY.

FIG. 4—VIEW OF CAB, L. & Y. RY. MOTOR CAR.

RECENT STEAM MOTOR CARS IN GREAT BRITAIN

BY CHARLES S. LAKE.

The system of working local and branch line traffic by means of self-contained motor cars has been widely developed on British railways during the last few years. The majority of these claim to be operating such cars at a considerable profit in comparison with the previous method of working with a tank locomotive and short train of ordinary cars.

On the Taff Vale Railway, the leading system of its kind in Wales, the motors are in daily use on all parts of the system, and substantial economies have been effected in the working expenses. This line, which is an agglomeration of branches, lends itself particularly well to the profitable employment of motor traction for lighter service. A statement has recently been issued setting forth the details of working costs respectively for the motor cars and a train comprised of a small tank engine hauling a train of four coaches. The net showing in this is that the motor cars can be run for 10.96 cents per train mile, whereas it takes 29.94 cents per train mile to run the engine and four coaches, a saving of 18.98 cents per train mile in favor of the motor. The comparison is based upon the operating charges of the two methods of working, including cost of coal, water, oil and supplies, cleaning, steam raising, etc., for the engines, lighting, cleaning and oil for the cars and repairs, renewals, wages, etc., in respect to both. The initial cost of construction is not considered. The Taff Vale cars number 16, of which 12 are daily in service, while 4 are kept in reserve. They perform 198 separate journeys daily and carry 6,700 passengers on the average during the same period. The cars are of two separate types, and one of the latest built (in 1906) is illustrated herewith.

This car is propelled by steam supplied by a boiler of peculiar construction, which is shown in one of the illustrations (Fig. 2). The fire box is in the center and there are two barrels with separate nests of flues and smoke boxes, one on either side of the fire box. The smoke boxes connect by uptakes to a single stack

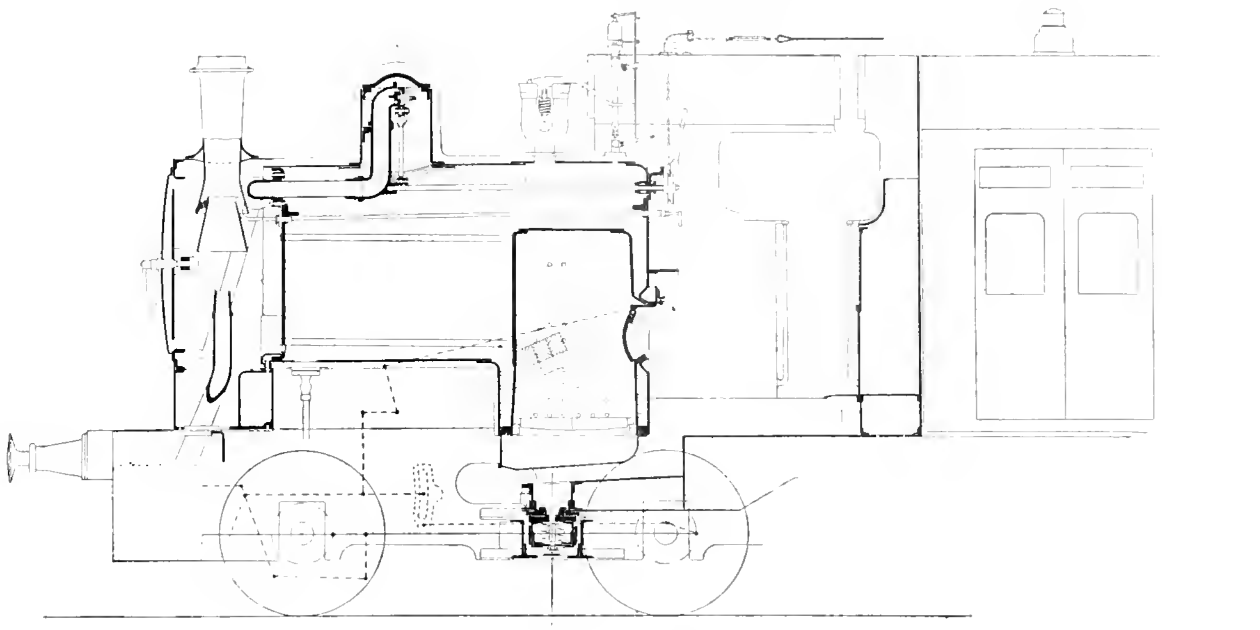


FIG. 5.—SECTION OF MOTOR TRUCK AND BOILER, LANCASHIRE & YORKSHIRE MOTOR CAR.

in the center just back of the dome. This boiler is arranged with the barrels transverse to the center line of the car. The smoke boxes are fitted with hinged doors, one of which can be seen on the outside of the car. Each barrel contains 232-1⅝-in. tubes, 27 in. long, giving a tube heating surface of 414.21 sq. ft., which together with the fire box heating surface of 50.63, gives a total heating surface of 464.84 sq. ft., the grate area being 10 sq. ft.

Steam is supplied at 180 lbs. pressure to a pair of 10½ x 14-in. cylinders. These drive on the forward wheel of the truck, which has a diameter of 42 ins. The slide valves are set vertically on the inside of the cylinders and are operated by a Stephenson link motion. The trailing wheel of this truck is 34 ins. in diameter, and the whole truck with the boiler and including the cab, really forms a small locomotive, and while the end of the motor car is also supported on the center bearing on this truck, the construction is such that the body can be easily detached and a new motor quickly put into place. It is stated that but twenty minutes is required for this change. The firing and operating are done from the forward end of the cab, where large windows give a clear view of the line. A limited supply of coal and water is carried.

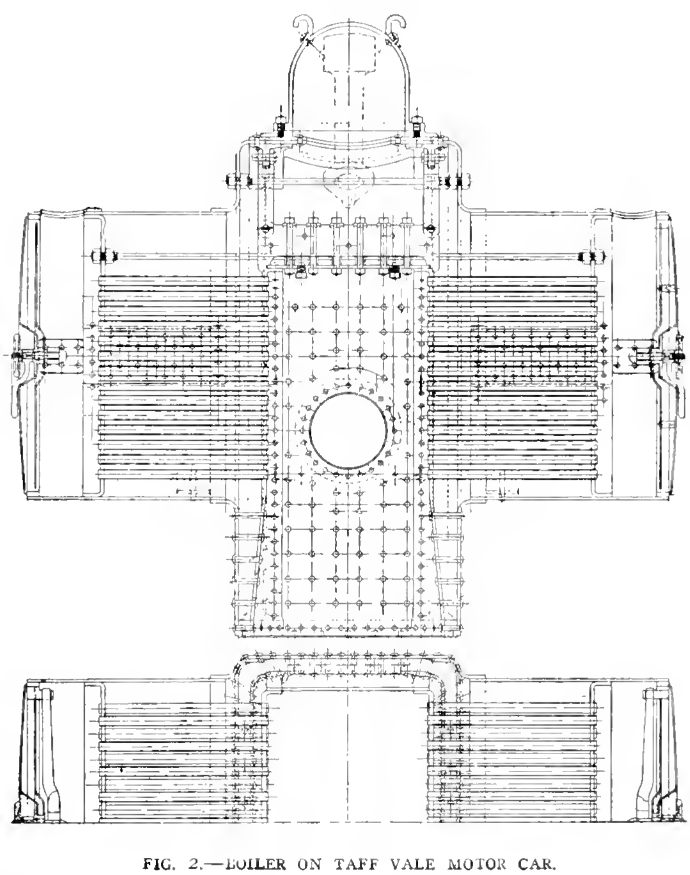


FIG. 2.—BOILER ON TAFF VALE MOTOR CAR.

The body portion of the car has three passenger compartments; first, a smoking compartment for third-class passengers next to the motor room, then a larger third-class compartment, and lastly, a small saloon for first-class passengers. The two third-class portions are divided by a cross gangway with double doors at each end for giving access to and exit from the compartments. At the rear end of the car is a conductor's room, from which the motor can be operated when the car is running with engine behind. The motor truck is fitted with steam and hand brakes, and there is also a hand brake on the car truck. This car is capable of traveling at 35 miles per hour on the level, and at 20 miles per hour on a gradient of 1 in 40. The accommodation is for 56 third-class passengers and for 16 of the first-class. Below are a few leading dimensions:

ENGINE.

Cylinders	10½ x 14 in.
Driving wheels, diameter	42 in.
Trailing wheels, diameter	34 in.
Wheelbase	10 ft.

BOILER.

Total number of tubes	464
Total number of tubes in each barrel	232
Outside diameter of tubes	1⅝ in
Heating surface in tubes	414.21 sq. ft.
Heating surface in firebox	50.63 sq. ft.
Total heating surface	464.84 sq. ft.
Grate area	10 sq. ft.
Working pressure	180 lbs.

WEIGHTS.

Weight (in working order) on drivers	42,000 lbs.
Weight of complete car in working order	100,000 lbs.

CAR.

Total length of body	53 ft. 4½ in.
Wheelbase of truck	8 ft. 0 in.
Total number of passengers	73
Total length over buffers (engine and car)	70 ft. 3⅞ in.
Total wheelbase	59 ft. 9⅞ in.

The other illustrations (Figs. 3-5) show one of the new cars recently put in service on the Lancashire and Yorkshire Railway, an important system operating in one of the most densely populated industrial portions of England. These cars are proving highly efficient and economical in working. They differ somewhat in design from the Taff Vale Ry. car.

The engine is connected to the car in a very similar manner,

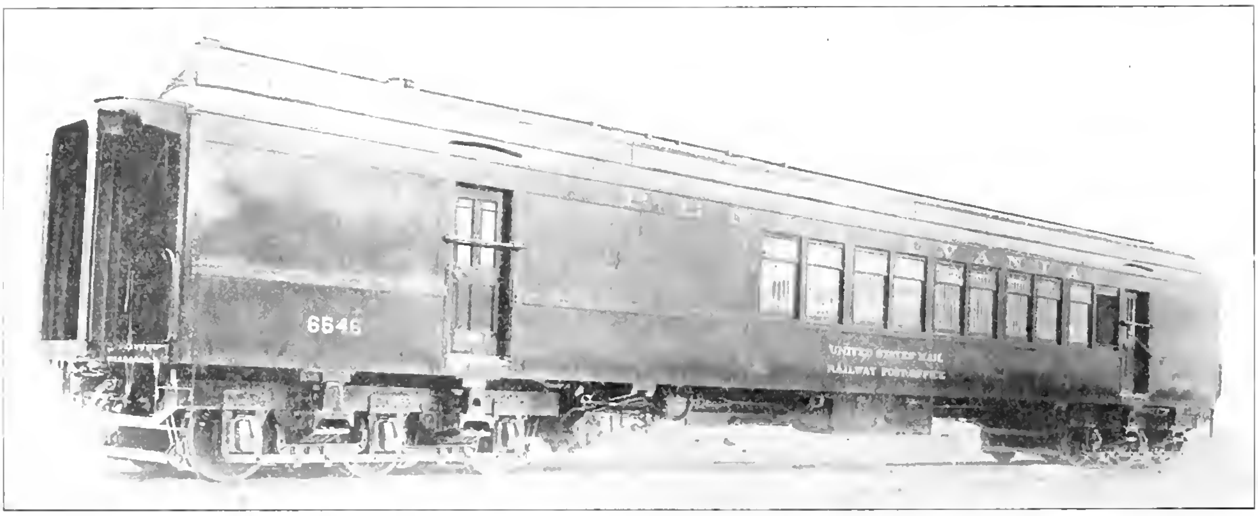
but it has a boiler of the locomotive type with side water tanks. The boiler is similar in design and width to existing Lancashire & Yorkshire Railway locomotive stock, allowing the use of many standard parts and fittings, thus reducing the cost of production. The cylinders are placed outside the frames and steam is distributed to them by superposed flat slide levers worked by Walschaert motion. The four engine wheels are of equal diameter and coupling rods are used. The main rods drive on crank pins in the rear wheels. The throttle valve, whistle, vacuum and hand brakes can be operated by the driver from either end of the car. The car body is divided into three compartments and a baggage compartment; two of these are for passengers and the third is a driver's compartment at the rear end. Only one class of passenger is carried. They are lighted by incandescent gas and warmed by exhaust steam from the engine. Electric bell communication is arranged on the engine and at the trailing end to insure proper control of the car. The motors run on gradients of 1 in 50 and 1 in 40, and have attained speeds of 35 to 40 miles per hour on the level. They have dimensions as follows:

CAR.

Length over buffers	69 ft. 5 in.
Length over car body	47 ft. 6 in.
Width of car body outside	8 ft. 6¾ in.
Width of car body over all	9 ft. 0 in.
Total wheelbase	54 ft. 8 in.
Wheelbase of engine truck	8 ft. 0 in.
Wheelbase of car truck	8 ft. 0 in.
Cylinders	12 by 16 in.
Weight in working order	107,280 lbs.
Weight on working wheels	73,080 lbs.

BOILER.

Heating surface, tubes	455 sq. ft.
Heating surface, firebox	54 sq. ft.
Total heating surface	509 sq. ft.
Grate area	9.4 sq. ft.
Steam pressure	180 lbs.



ALL-STEEL 70-FT. POSTAL CAR—PENNSYLVANIA RAILROAD.

ALL STEEL POSTAL CAR.

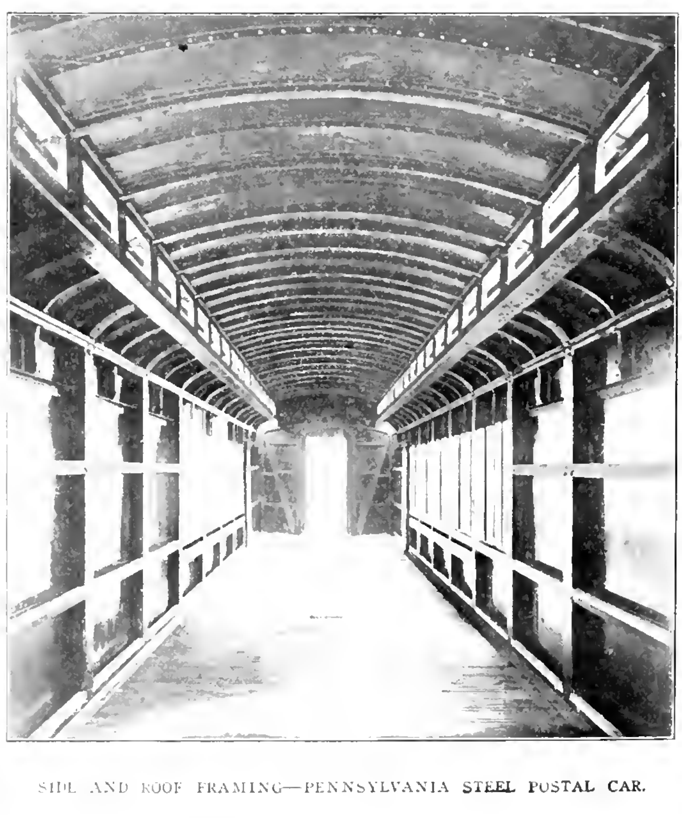
Pennsylvania Railroad.

The Pennsylvania Railroad has recently completed what is said to be the first absolutely non-combustible postal car ever built. This car was designed and built at the Altoona shops of the company, and is now in service between New York and Washington, D. C. It is 70 ft. long, or 10 ft. longer than the present standard postal car, and is constructed throughout of steel and fireproof composite and asbestos board. There is altogether 370 lbs. of wood in the car, generally in small pieces, for various purposes for which no other material would be as suitable. By making the car 70 ft. long it has been possible to re-arrange the interior so that the distributing and sorting racks are in the centre of the car and the storage spaces are at either end, thus placing the mail clerks in the easiest riding section of the car, as well as providing much larger storage mail space and making it unnecessary to turn the car at terminals.

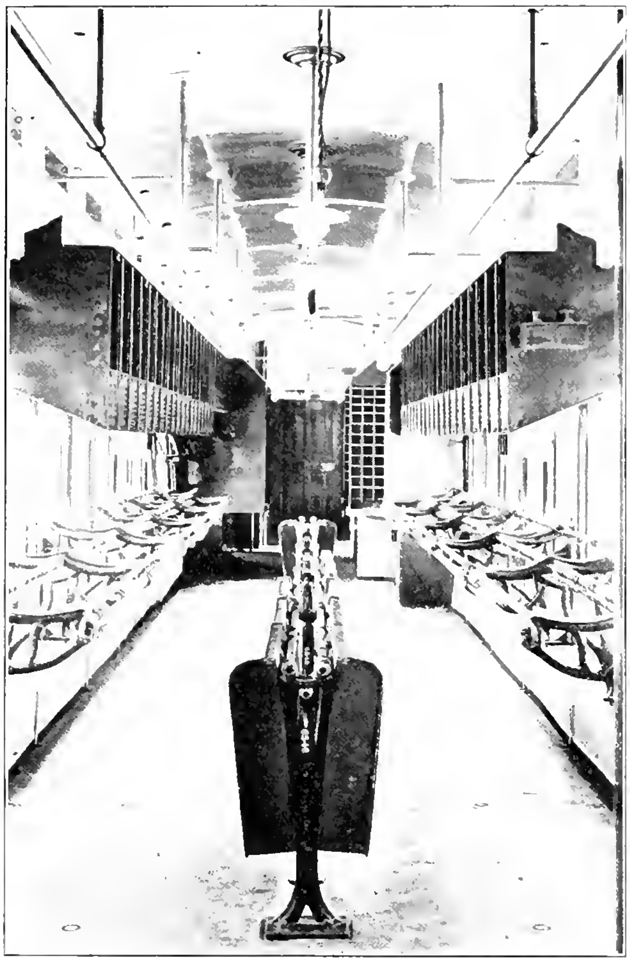
The frame work throughout, side sheathing, letter cases, drawers, sorting boards, doors, etc., are of steel. The floor is of cement laid on corrugated steel plates. The interior finish is generally of composite board, and all inside lining and steel plates are covered with asbestos cloth glued to the sheets, which serve as sound and heat non-conductors.

The general scheme of construction follows very closely that used on a steel passenger car recently built at the same shops, which is now in experimental service. This consists of carrying the whole weight of the car and its load on a very heavy box girder type of centre sill, which consists of two 18-in. I beams with two cover plates ½ x 24 in. This girder is set at such a height from the rail as to permit the draft gear to be placed between the centre sills at a point near the centre line, so that all pulling and buffing strains are transmitted in a direct line through these sills.

The body of the car is supported from the centre sills by two cross bearers and the end sills. The cross bearers are located about 10 ft. from the end sills and are about 32 ft. apart. They are constructed of pressed steel shapes and provided with cover plates, so as to make a very strong and rigid support. The end



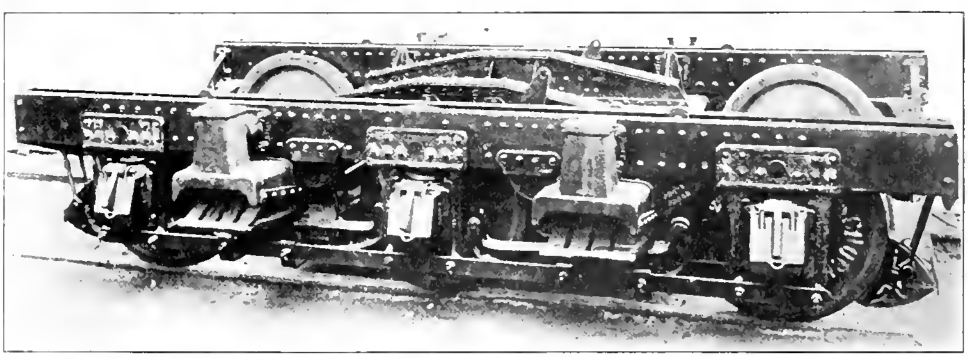
SIDE AND ROOF FRAMING—PENNSYLVANIA STEEL POSTAL CAR.



INTERIOR OF PENNSYLVANIA STEEL POSTAL CAR.

sills are of similar construction. The car is not provided with body bolsters and the whole weight of the body is conveyed to the cross bearers and end sills by means of the side sills, which really form the bottom members of a plate girder made up of the side sills, the side sheathing below the windows, and the belt rail, the web plate being stiffened and reinforced by the side posts. In the case of the postal car this girder is interrupted at the doors, but since it carries simply the weight of the superstructure of the car and the location of the doors is outside of the point of support on the cross bearers, this does not weaken the construction in any material way.

A very strong body end construction is provided by two 12-in. I-beams located on either side of the end door with the web parallel to the center of the car and securely fastened to the center sills at the bottom and to a cross beam of channel section at the top. The side posts and carlins are of pressed steel shapes of channel section, and the roof and side sheathing above the windows, as above mentioned, is of steel.



SIX-WHEEL TRUCK, STEEL POSTAL CAR—PENNSYLVANIA R. R.

The trucks are of the six-wheel type of a special design, which includes no equalizers proper, the wheel pieces of the truck acting in this capacity. The truck bolsters are double and extend out beyond the truck frame for a sufficient distance to allow the side bearings to be located on the side sill. They are provided with spring centering devices. There being no body bolster the center plate is fastened to the center sills.

The car is lighted by electricity, using the axle light system, with sufficient storage batteries to furnish 280 ampere hours. Candle lamps are provided for cases of emergency. It is heated by direct steam. A new arrangement is noticed in the windows by the provision of a narrow upper sash which can be lowered, and which is provided with glass in its lower half, and a fine screen in the upper half, so that when lowered it allows ventilation without leaving an opening for cinders to enter or mail matter to be lost, but when raised it presents the usual glass area. Similar provision has been made in connection with the ventilators by the location of permanent screens outside of each sash.

The car is equipped with Westinghouse friction draft gear and rolled steel wheels. It weighs 128,500 lbs. complete and has a length over buffers of 74 ft. 9¾ in. and a width of 9 ft. 11½ in. over eaves. The inside length is 70 ft. 8¾ in., and the inside width 9 ft. ⅝ in.

Motor Cars for the Intercolonial Railway.—The Intercolonial Railway has ordered three motor cars, the motor equipment for which will be built at its own shops at Moncton, N. B. The cars will be 60 ft. in length over end sills and will seat 40 passengers in the passenger compartment and 12 in the smoking room. The framing will be of wood throughout, being sheathed on the outside with cherry. The specifications for the locomotive portion of the car provides that it is to be easily detached from the car body. The engine truck is carried on four wheels coupled, the car body being supported on a cast steel frame attached to the equalizing spring gear of the locomotive. The boiler is to be of the vertical type, so attached to a cast steel saddle that it can be easily removed. It will have 728 sq. ft. of heating surface; 11.5 grate area, and a working pressure of 180 lbs. The cylinders will have a diameter of 12 in. and stroke of 16 in. The car is to have a speed of 25 miles per hour on a 1 per cent. grade; the driving wheels being 42 in. in diameter.

Cause of Woodlawn Wreck.—The computations which I have made or examined indicate that the front outer driving wheel of the electric locomotive may have exerted a pressure against the outer rail on the 3-degree 5-minute curve of from 5,000 to 10,000 pounds at a speed of 60 miles per hour. Taking the highest figure, using 17,000 pounds for the ultimate shearing strength of a spike, as determined by Professor Lovell, and considering the pressure as distributed over two spikes, the factor of safety is 3.4, which is satisfactory. These computations hence indicate that the accident must have been due to some other cause than the radial pressure developed under the normal action of the locomotive.—*Prof. Mansfield Merriman.*

Surprise Signal Tests.—During a recent series of surprise tests of signals on the Pennsylvania R. R., 97 per cent. of the enginemen complied with all rules and the other 3 per cent. stopped their trains after passing the signals.

Never forget that you must begin at the bottom and not at the top if you desire results. Scattering seeds over an unprepared surface is a waste of time! You must plow first! Then the results will be in direct proportion to the persistence with which the work is followed up.—*Mr. Geo. G. Yeomans before the Railway Storekeepers' Association.*

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The slight delay in issuing this number is due to the fact that we have made a change in our printing arrangements. This has been done at a considerable expense and we trust that our readers will be pleased with the improved appearance of the paper. In addition to other changes new type has been furnished throughout for both the advertising and editorial sections.

The type of rail motor car which is the most popular in Great Britain, where there are more of these cars in operation than in any other country, is a steam propelled car with the passenger section separate and detachable from the source of power. In some cases the boiler and engines are mounted on a truck which also supports one end of the car, and in others an ordinary light passenger car is coupled to a separate small tank locomotive. The advantage of this is, of course, the ability to remove the machinery section for repairs without laying up the whole car, and is one which would seem to be well worth considering.

There is now either in operation or in course of construction in this country a sample of each different type of passenger service car of the fireproof all-steel design. These include one baggage car, four mail cars, three passenger coaches, one dining car, one sleeping car and a large number of suburban cars. There are also a number of all-steel motor cars of the gasoline, gasoline-electric or straight steam types in operation or under construction. Many well informed men are of the opinion that eventually all passenger service cars in the country will be built of steel, and while the probabilities are that this will be true in cases of special service such as suburban or underground trains, it is still a little early to form any conclusions as to general service. However, it is clearly evident that a fair trial is to be given this new construction, and a few years hence we will probably have some facts on which to base prophecies for the future.

The results of the service given by the two all-steel Union Pacific box cars, which have recently been designed and placed in service, and are described on another page of this issue, will be awaited with great interest by the railroads of this country. While the cars will probably prove to be sufficiently strong, although the side sheets are rather light, it is questionable whether they will prove successful for general merchandise purposes. The service given by two or three hundred iron box cars on the Baltimore & Ohio Railroad, the first ones of which were built and placed in service in 1862, may be of interest in this connection. Previous to that time a number of cars similar to a tank car, but with doors on the ends, were used for carrying powder. These were not suitable for general merchandise purposes and were succeeded by the box cars which had iron bodies and wooden underframes. The iron sheets were ⅛ inch thick or the same thickness as the steel on the Union Pacific box cars. These cars were found to be unsuitable for general merchandise purposes or at least for commodities which might be affected by high temperatures. During the summer months they were said to be regular bake ovens. When they were withdrawn from general service and used for hauling lime-stone in bulk a great deal of trouble was caused due to sweating. When the first steel postal cars were built the metal was not covered on the interior and during cold weather more or less trouble was caused by frost gathering on the sheets inside the car. On the later cars the sheets were covered on the inside with a composition board or some similar material. If only a few steel box cars are placed in service they can, of course, be used for commodities which might not be affected by these causes, but if these features should prove very objectionable it will prevent their coming into general use even though they may be satisfactory in other respects.

The practical man with no technical school training who has made his mark in the technical field is entitled to our greatest respect. The average man of this kind is inclined to place a premium on technical education, realizing that he might have been even more successful if he had been equipped with it. Tech-

nical education does not make the man, but a young man, if he has the proper kind of stuff in him, can greatly improve his prospects by acquiring such an education. It is with considerable regret that we find a prominent manufacturer, well known in railroad mechanical circles, advising the young men and boys in his establishment, in a publication issued by his company, that it would be a waste of time and money for them to attend a technical school, and stating that he considered practically all of these schools as being gigantic humbugs.

That the railroads of this country do not take this view of the question is indicated by the fact that the greater number of them have either taken steps toward improving the condition of their apprentices and giving them at least the rudiments of a technical education, or have such plans under consideration. Not only this, but there is a demand for the young men from our technical schools, and this not alone in the drawing room, but also in the shop. Any number of these young men who have spent a few years after graduation beginning at the bottom in the railroad shop and working up, are to-day producing splendid results in assisting to cut down the cost of production and increase the output. The following extracts are reproduced from a Philadelphia dispatch dated March 9 and are of interest:

"Men with college training are to be in greater demand on the Pennsylvania Railroad henceforth. The management is making special efforts to secure apprentices who have a real technical education. The man who has it proves himself, other things being equal, to be more valuable to the railroad than the one who has been forced to get along without this training."

"We must have more college men on our lines," said one of the officials, speaking of the company's improvements and need of new men. "Of course, being a graduate is not enough in itself; there has to be ability to insure promotion. There will still be employees without the record of a day in college who will rise to the top; some men can't be kept down. But the fact remains that technical training is what a railroad man ought to have, and we intend to get those who have it."

"The percentage of college men in the service of the principal railroad systems is becoming larger every year, and such inducements as those offered by the Pennsylvania are expected to make the attraction for graduates still greater. With the traffic of the railroad increasing by leaps and bounds every technically trained man who is ready to work will be able to find a place."

PROGRESS IN TRANSPORTATION.*

By G. M. Basford.†

Macaulay realized the importance of commercial communication when he said: "Of all inventions, the alphabet and printing-press alone excepted, those inventions which abridge distance have done most for civilization." Steam has exerted a most wonderful influence upon civilization. It was really contemporaneous with the new American republic and has been most powerful in its development.

Watt completed his engine in 1787, while the Federal Convention was sitting in Philadelphia. Fifty years later Stephenson's locomotive was a success, and people now see that railroads at once became necessary. Their introduction was providential because without them these States could not have developed, and, of course, no close union of the States would have been possible. Without the railroads the Civil War might even now be dragging along because in the old days an hundred-years' war was not unheard of. The far west the middle west and the great northwest waited for the railroads.

The vital influence of the railroad is nowhere better indicated than in the amusing senate debates of 1843, on the Oregon bill, when seen in the light of recent progress. Senator McDuffie of South Carolina ridiculed the idea of ever taking Oregon into the Union because it would require ten months for the representative to travel to the Capitol and return. Now we may go from Boston to Portland, Oregon, in less time than it took John Hancock to go from Boston to Philadelphia.

In 1783, two stage-coaches sufficed for all the transportation business by land between Boston and New York. Starting at 3:00 A. M., Providence (44 miles away) was reached at 10:00 P. M., if everything went well. The speed, we are told, depended largely upon how often the assistance of the passengers was required to lift the wheels out of the mud. We can hardly appreciate the difficulties of those days; and when we consider that Washington conducted the Revolution without the aid of railroad, steamboat or telegraph, and when we compare the military movements of that war with our latest war, we can better understand the progress that has been made.

April 13, 1907, will be the 58th birthday of the Pennsylvania Railroad. In 1846, the railroad was 20 miles long. It now has about 16,000 miles of track.

In 20 years from its inception the Atchison, Topeka & Santa Fe Railroad had grown to a total length of 10,000 miles—which is one-half that of Great Britain and Ireland, one-half that of France and Russia and two-thirds that of Germany. Its rails would reach one-third of the distance around the earth, and it has on its rolls 10,000 more men than were in the United States army at the beginning of the Civil War. Its organization is as complete as that of the United States army and is in pleasing contrast to the army in regard to internal strife and bickering.

Another form of growth is seen in the contrast between the New York Central property today and when the road from New York to Albany was owned by sixteen different companies. On January 1, 1906, fifty-four roads were combined under one operating management, as the "New York Central Lines."

In October, 1905, Mr. E. H. Harriman and party, on their way from the Orient, crossed the North American continent in a memorable trip with a rail journey of 3,239 miles, which began October 23rd, 30 minutes after 3:00 o'clock at San Francisco, and ended at 42 minutes after 7:00 o'clock on October 26th—or 73 hours, and 12 minutes later. The path included the Southern Pacific to Ogden; the Union Pacific, from Ogden to Omaha; Chicago & Northwestern, from Omaha to Chicago; Lake Shore & Michigan Southern, from Chicago to Buffalo; and Erie Railroad, from Buffalo to Jersey City. An average speed of 43.3 miles per hour was maintained across the entire continent, or 19 hours and 15 minutes faster than any previous trip from San Francisco to New York. During dinner the first evening from San Francisco the Sierra Nevada Mountains were crossed at an elevation of 7,018 feet. Great Salt Lake was crossed over the Lucin cut-off.

The entire trip of 7,775 miles from Yokohama to Jersey City was covered at an average speed of 23.7 miles per hour, including all stops and transfers. For this service between San Francisco and Jersey City thirty locomotives were required; and that such a performance, conducted without pause or delay of any kind, could be carried out with perfect comfort to the travellers, speaks volumes for the transportation organizations which were involved. Not only does it speak volumes for the organizations themselves, but for the co-operation existing between these organizations which rendered it possible for one to take up and perfect that which the previous one had brought to its hands. It will be remembered that the daughter of the President of the United States was a member of the party, and that no attempt was made in the direction of high speed. The safety and comfort of his guests was Mr. Harriman's first consideration throughout the journey.

In this development, which is the most remarkable of modern times, many lives have been spent for the benefit of others; and, that this statement is literal, may be seen by anyone who crosses the western deserts to find the graves of railroad pioneers strewing the way. To again mention the Santa Fe Railway—this line crosses mountain and desert for a large part of the way parallel and in sight of the old Santa Fe Trail; and, if the stories of this trail could be given us, it would be full of records which would stir men's blood.

We also owe much to faithful, high-minded men, some of whom are gone, who—while not directly connected with the actual development—have nevertheless been in most intimate contact with it. I refer to the technical newspaper men who played an exceedingly important part in connection with this growth

* From an address before the Technical Publicity Association, New York, on their "Steam Railroad Night," February 28th, 1907.

† Assistant to the President, American Locomotive Company.

which has become so important. We owe more to the technical papers which have devoted themselves to the field of transportation—more than is likely ever to be paid in appreciation or any other way. It is a fact, that some of the most vital features which have tended to unite and improve transportation methods in the past, originated in the offices of these papers. While conditions have changed and are changing, these influences are still strong, and the members of this Association should bear in mind these facts which have been casually mentioned.

In connection with the responsibilities of our members, it would be well to remember that there are strong technical papers in this field to-day, and papers which are earnestly directing their efforts towards advancement and improvement which will always be necessary. In dealing in a business way with these publications it is not out of place to suggest that those which really have borne the burdens of this effort, and are still bearing them, are worthy of most careful consideration.

MOTOR CARS IN FOREIGN COUNTRIES.

In an effort to ascertain the usefulness of railway motor cars to be operated in connection with the regular steam service, the Pennsylvania Railroad last fall commissioned a committee of three officials to go to Europe and see what had been done there along this line. The report of this committee which has just been submitted includes the following:

"Rail motors, costing from $8,000 to $10,000 each, have been introduced to a greater or less extent by all principal railways of England; also by several on the Continent.

"In some cases they have entirely displaced the steam passenger service on branch lines, but are generally being used for supplementary service in connection with other trains.

"The car is in charge of a guard, who issues tickets and collects fares, besides performing necessary duties in connection with the handling of luggage and parcels. He also keeps the necessary train records. On lines where motor cars are operated the freight train service is performed by a regular locomotive.

"It appears that where rail motor service has been established travel has increased to a considerable extent. Within itself, the service is not remunerative, but the expense would seem to be warranted when its value as a feeder in creating additional long-distance travel from the main line steam trains is considered.

"Operating officials of roads on which this character of service has been established were rather enthusiastic as to its possibilities. The mechanical officials, however, were not favorable to it. It was admitted that there is a slight saving in fuel, but it is claimed that this is more than offset by the increased cost of maintenance and the loss of service while undergoing repairs.

"On the Continent, while this service is in actual operation to a limited extent in Germany, France and Italy, railway officials still consider it to be in an experimental stage.

"We inspected the Great Western Railway motor service from Southall to Ealing, both stations being suburban to London. The speed ranged from twenty to forty-five miles an hour. The driver said the car was capable of fifty miles per hour. The car ran smoothly, without noticeable vibration, and had been in successful operation for three years. The London, Brighton & South Coast Railway has two gasoline motors in service at Brighton. Each car is equipped with two 30-h.p. Daimler motors suspended from the frame. Noise and vibration were noticeable while these cars were standing with the motors running. There was also a very disagreeable odor from the gasoline.

"The London, Brighton and South Coast Railway has small detachable steam locomotives at Brighton, which are attached to trailers. Local officials said this service was more satisfactory than by the gasoline cars.

"German railways, under government management, have been experimenting with rail motors two years, using for purposes of comparison a Serpollet car (steam, with coal fuel), a Milnes-Daimler car (gasoline), and an Accumulator car (storage battery), also a small locomotive and coach. We were told that the experiment so far showed the steam locomotive and coach to be the most economical and successful.

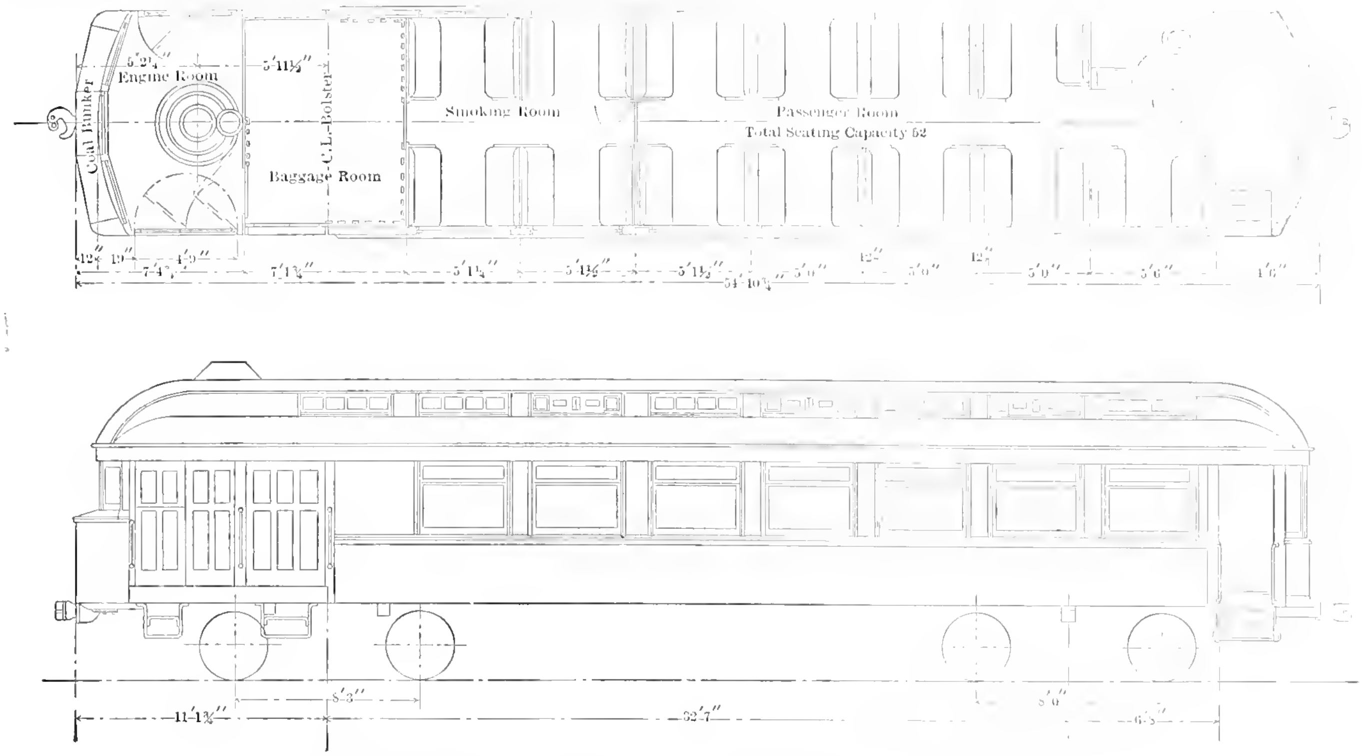
"With the benefit of this experience the committee is of opinion that the installation of self-contained motor cars for passenger service on certain branch lines largely depends upon the gradients, the possibilities for increased travel and the possible saving from a reduction in the train crews. A small tank locomotive and car, equipped for operation in either direction without turning, commends itself as the most elastic adaptation of the rail motor which came under our observation and appears to be in the line of future development abroad."

The Man, Not the System.—In my whole work on the Santa Fé I have found that system alone is not sufficient, that statistics alone are not sufficient, and, to branch away from storekeeping for a moment to a different branch, the thing that has struck me most is that in the engine it is not the type of engine, it is not the weight of engine, it is not the style of engine that counts in mechanical operation, it is the master mechanic who has charge of that engine. One master mechanic will make a light, old, half worn-out engine do better work than some other master mechanic will get out of a modern engine. The opposite is also the case. A splendid modern engine with a good master mechanic looking after it will do stupendous work, but it is not the type of engine that counts nearly as much as it is the type of man that is back of the engine, and I think that that same thing is true of storekeepers as it is of master mechanics. It is the storekeeper who counts, the man who is interested, enthusiastic and pushing in his work, and if you have that kind of a man he will evolve a system and profit by other systems, and deliver the goods.—*Mr. Harrington Emerson before the Railway Storekeepers' Association.*

Automobile Baggage Trucks.—For some time past there has been in use at the Broad Street Station of the Pennsylvania Railroad in Philadelphia, three baggage and mail trucks which are propelled by electric motors taking current from storage batteries. In general appearance they look much the same as the hand-pulled truck of large size. The batteries are mounted below the platform and the motors drive the wheels through gears. The speed is controlled by a small lever on the tongue, by which they are steered, and is so arranged that if the tongue is dropped or the operator lets go the handle, the current is shut off and the brakes applied. The operator walks ahead of the truck the same as if he was pulling it. These trucks have been very satisfactory and it is planned to add more in the near future.

Aerated Steam.—Scientific research has recently produced another and much more efficient method of increasing the thermodynamic value of the steam and its working efficiency than simple superheating. This is the Field-Morris system of what may be called the aeration of the steam by forcing into it under suitable pressure a definite and exact proportion of air, and superheating the mixture before allowing it to pass to its work in the cylinders. This mixture has been found, both experimentally and in ordinary practical working, to effect considerably more than natural steam is capable of, whether superheated or not.—*Mr. F. A. Lart in the Times Engineering Supplement.*

Railroads Which Pay Pensions.—It is said that the New York Central Lines will at an early date be included among the systems having pension departments. The list of those having these and the year in which they became effective is as follows: Baltimore & Ohio, in 1884; Pennsylvania Railroad, in 1900; Chicago & Northwestern and Illinois Central, in 1901; Southern Pacific lines, Union Pacific, Oregon Railroad and Navigation, Oregon Short Line, Philadelphia & Reading, Delaware, Lackawanna & Western, Buffalo, Rochester & Pittsburg, and Canadian Pacific, in 1903; Atlantic Coast Lines, in 1904; Atchison, Topeka & Santa Fe, Jan. 1, 1907.—*Railway World.*

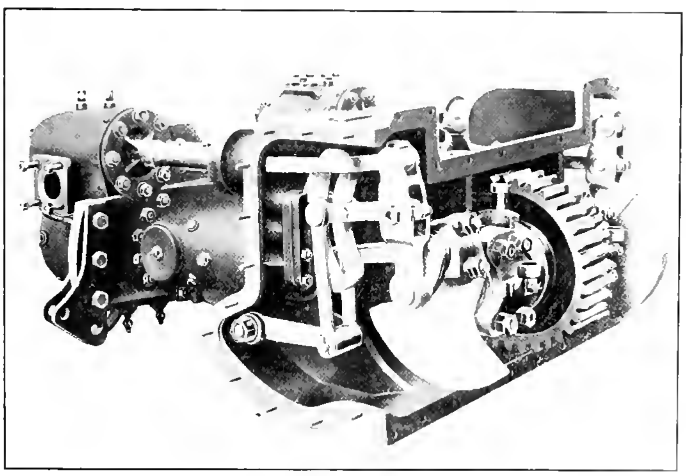


ELEVATION AND PLAN OF STEAM MOTOR CAR—CHICAGO, ROCK ISLAND & PACIFIC RY.

GANZ STEAM MOTOR CAR.

Chicago, Rock Island & Pacific Ry.

The Chicago, Rock Island and Pacific Railway Co. is soon to receive a Ganz self-propelled steam motor car from the Railway Auto Car Company, New York, the American company which controls the patents and manufacturing data for the Ganz system. From the general plan and elevation shown herewith, it will be seen that it is a car having a total length over end sills of 54 ft. 10¾ in. and a seating capacity of 52 passengers, including 16 in the smoking compartment. A baggage room 7 ft. 1¾ in. long is located just ahead of the passenger compartment and ahead of this is the motorman's compartment at the forward end of the car, which contains the generator and accessories, and is 6 ft. 4¾ in. long over all. The coal bunker is supported over the front end sill and the coal is removed through a small sliding door opening into the motorman's compartment. The coal bunkers carry sufficient fuel for a continuous run of 50 miles.



STEAM MOTOR IN GANZ MOTOR CARS.

The feed water for the steam generator is carried in two longitudinal steel tanks suspended from the underframe of the car. These tanks have a total capacity of 600 gallons or sufficient for a continuous run of about 60 miles. The steam generator, of the standard Ganz type, is 42 in. outside diameter. This steam generator is capable of developing a maximum of 120 h.p. in conjunction with the compound steam motor which is mounted in the forward truck and drives on the rear axle thereof.

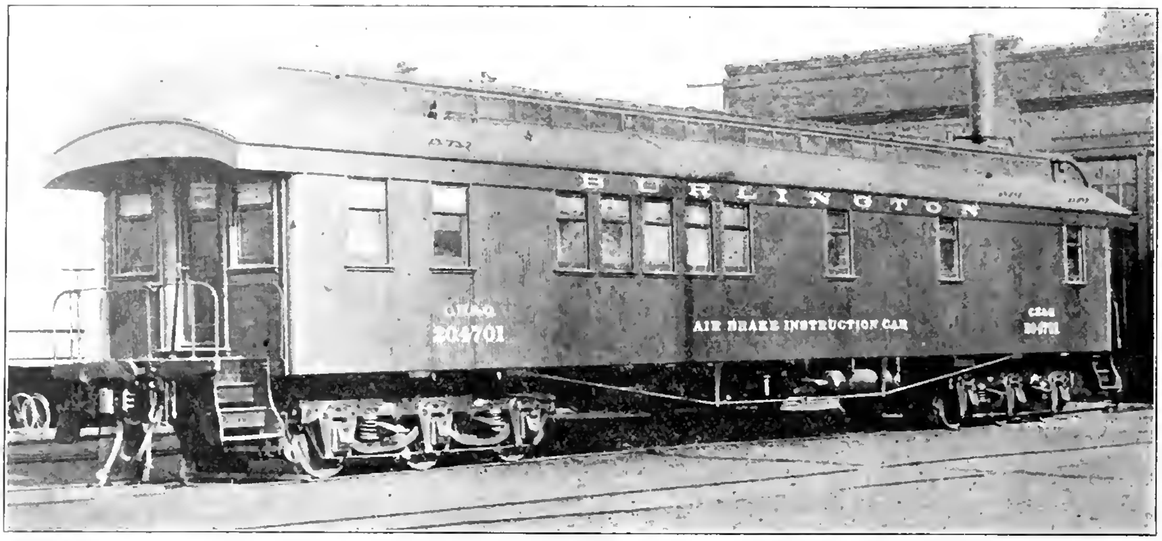
A view of the steam motor with the cover enclosing the gears and link motion removed is given in one of the illustrations. This motor has compound, steam-jacketed cylinders, and is entirely enclosed. The gear case is partly filled with oil, so that all moving parts receive a continuous and thorough lubrication. The normal speed is 600 revolutions per minute, although it can be operated satisfactorily up to a speed of 900 revolutions per minute. The working pressure is 270 pounds per square inch, the steam being superheated. The motor is controlled entirely by levers conveniently located at the right-hand side of the motorman's compartment.

The car body is of all steel construction with the interior finished in quartered oak. The general scheme of design of the car body is the same as is used on most of the all-steel passenger coaches, which have been, or are being, built, i. e., the vertical load of the car and its lading is carried by the sides of the car below the belt rail, which are in the form of deep plate girders, while the buffing strains are taken care of by relatively light longitudinal center sills. The total weight of this car in working order fully loaded is 30 tons. The car is equipped with Westinghouse automatic brakes, the air compressor being of the axle driven type and mounted in the trailer truck.

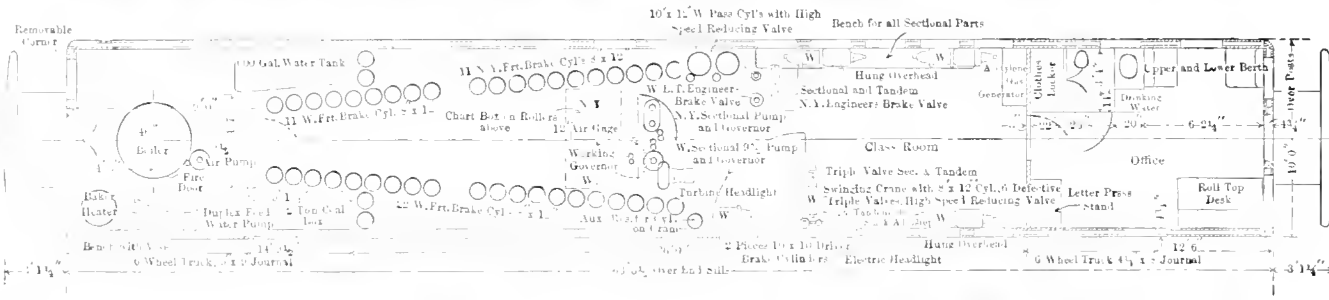
The car is designed to maintain a speed of 35 miles an hour on a level track, 24 miles an hour on a 1 per cent. grade and 15 miles an hour on a 1½ per cent. grade. It is also capable of hauling a trailer at a speed of 30 miles per hour on a level track and 15 miles an hour on a 1 per cent. grade. The fuel is to be coke and the consumption is not to exceed 16½ pounds per mile.

This is the first standard car of the Railway Auto Car Company to be built and delivered in this country, although orders for other cars of this general type are now being executed.

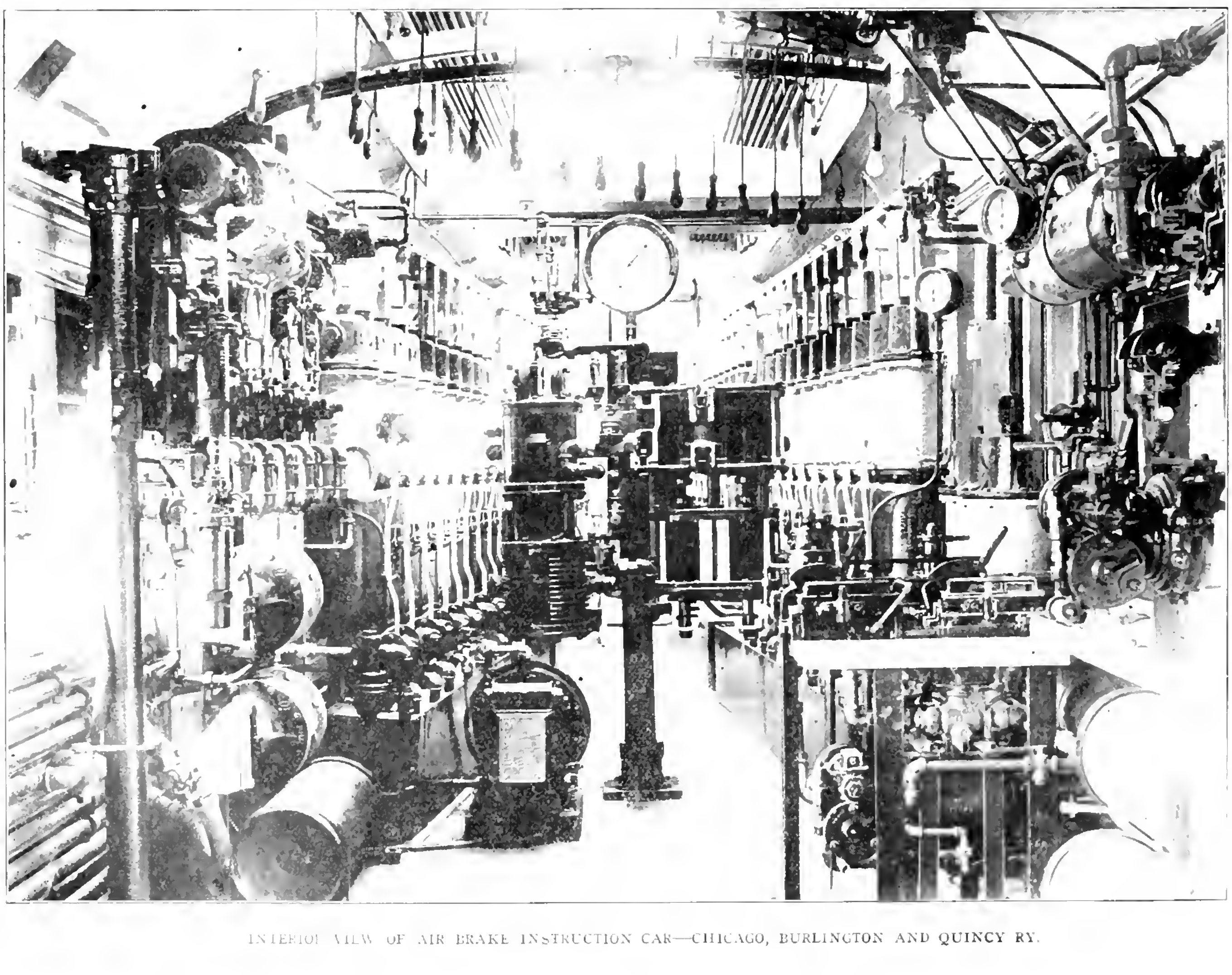
Rolling Stock of the Pennsylvania.—Between the years 1800 and 1906, inclusive, there were 1,216 new locomotives added to the equipment of the Pennsylvania System, and 1,337 locomotives rebuilt, all of which increased the total tractive effort from 73,200,000 to 106,100,000 lbs. During the same time there were 122,718 freight cars built or rebuilt, giving an increase of 4,927,000 tons in loading capacity.



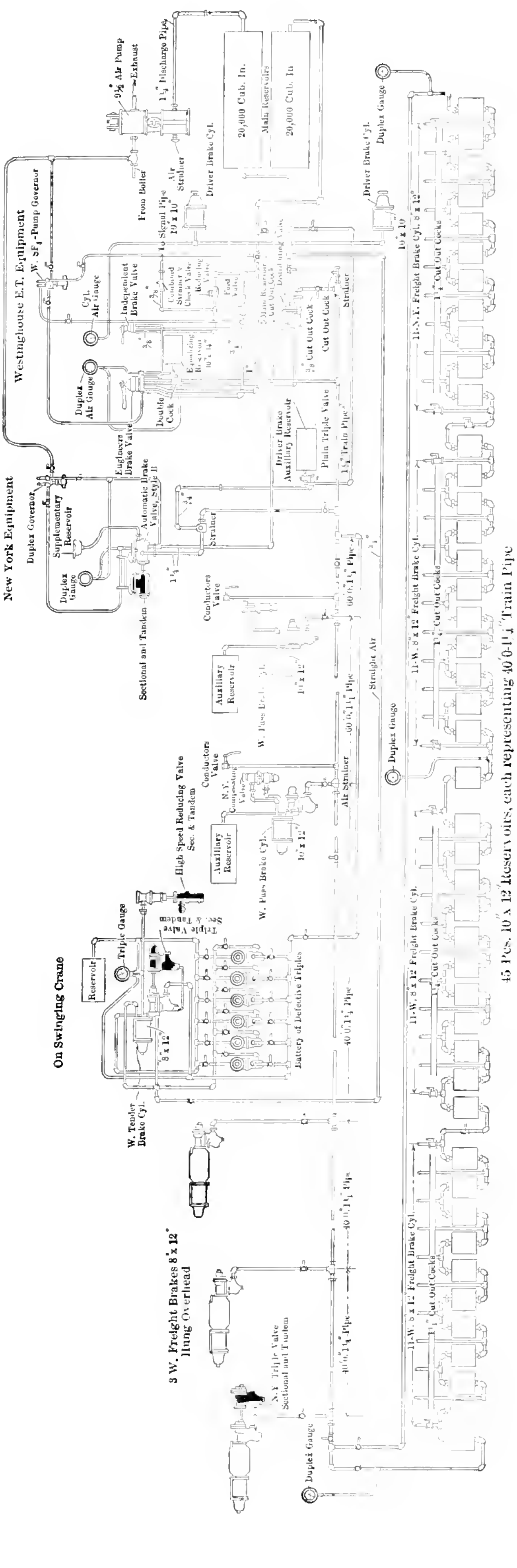
AIR BRAKE INSTRUCTION CAR—CHICAGO, BURLINGTON AND QUINCY RY.



FLOOR PLAN OF AIR BRAKE INSTRUCTION CAR.



INTERIOR VIEW OF AIR BRAKE INSTRUCTION CAR—CHICAGO, BURLINGTON AND QUINCY RY.



PIPING DIAGRAM OF AIR BRAKE INSTRUCTION CAR—CHICAGO, BURLINGTON AND QUINCY RY.

AIR BRAKE INSTRUCTION CAR.

CHICAGO, BURLINGTON & QUINCY RAILWAY.

The Chicago, Burlington & Quincy Railway has just completed at its Aurora shops, a new air-brake instruction car, which contains many points of interest, especially in connection with the best location and arrangement of the apparatus.

Reference to the illustration will show that the car contains a most complete instruction equipment for both the New York and Westinghouse systems, as well as for electric and acetylene lighting systems. The view showing the floor plan taken in connection with the interior view of the car, will show that by careful study a very large amount of apparatus has been collected into a small space in such a manner that practically all the parts needed for instruction on any particular point can be brought into clear view of the men seated in the class-room. This will permit the proper and convenient instruction of the men without necessitating their following the instructor to various points of the car for demonstration of particular details, thus not only facilitating but also improving the results of the instruction.

The car body, which was converted from a mail car, is divided into three compartments—an office 12 ft. long; a class-room 41 ft. long, and a boiler-room 9 ft. long. The office is arranged with a roll-top desk; upper and lower berths; wardrobe and toilet room. Above the desk is placed a triplex gauge for indicating the train line, signal line and brake cylinder pressures underneath the car. The boiler-room contains a 40-in. vertical boiler carrying 200 lbs. pressure and equipped with shaking grates and an extension smokestack. Water is supplied from a 600-gallon water tank by either an injector or a duplex pump. A 9½-in. air pump, which supplies air for the apparatus in the class-room, is attached to the boiler. A Baker heater is included for warming the car. A coal-storage space, with a capacity of 2 tons, is located on the oposite side of the car from the water tank.

In the forward end of the class-room there is space for 18 men to be seated on folding chairs. The 52 brake cylinders, consisting of 36 Westinghouse 8 x 12 freight brakes; 11 New York 8 x 12 freight brakes; 2 Westinghouse 10 x 12 tender brakes, and 2 Westinghouse 10 x 10 driver brakes, are all in full view from the seats in the class-room. The freight brakes stand vertically in two rows on either side of the car, the rows converging toward the boiler end for the purpose of bringing the piston rods in clear view. The other brake cylinders are mounted horizontally below the lower deck, where they can be easily seen. One tender brake cylinder and connections is bolted to a swinging crane, on which is also mounted six triple valves having various defects, any one of which can be connected to the cylinder. On the interior view this crane is shown swung against the left wall of the car. To the cylinders that are set in a vertical position, the triple valves are attached by means of a special elbow, which brings them into a horizontal position, the same as they occupy underneath a car.

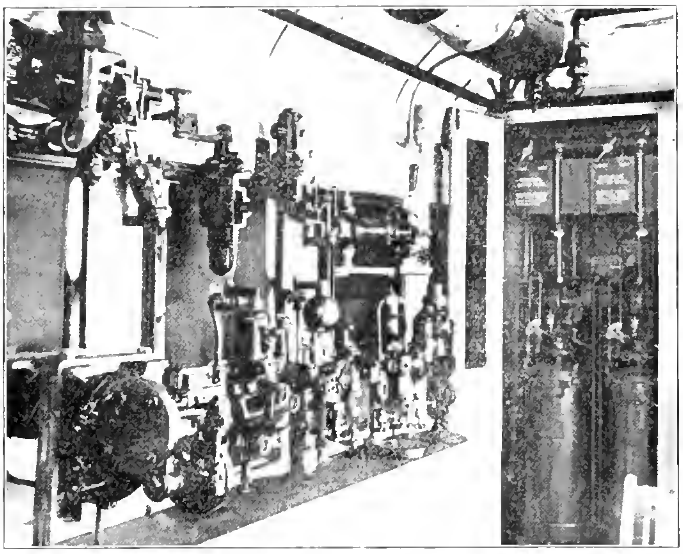
To do away with the large amount of piping usually found in an instruction car, for representing the train line, 45 of the brake cylinders are connected to 10 x 12 in. equalizing reservoirs, which have practically the same capacity as a 40 ft. 1¼ in. train pipe, and have been found to give the same results as that amount of actual piping. These are placed on the floor and are enclosed in a galvanized iron casing.

As can be seen from the illustration showing the piping connections, the brakes can be operated in various combinations, either by the Westinghouse E. T. system, or by the New York system. Practically all operating features of both systems are connected in tandem with a sectional part, so that the interior workings can be easily demonstrated. Some of this apparatus is hung on swinging cranes in the centre of the car, where it can be brought into view when needed.

The air signal apparatus consists of a complete equipment for fourteen 60-ft. cars, the piping being placed along each side of the clere story. The signal cord handles will be noticed in the interior view.

Colored Westinghouse and New York diagrammatical charts are mounted in a case, which, when in use, can be lowered in front of the class and at other times is secured against the roof.

A bench is provided on which are placed the sectional parts of air-brake apparatus, lubricators, injectors and steam-heat apparatus. The car is also equipped with Pyle electric light apparatus and the Adlake acetylene lighting outfit, both of which



SECTIONAL PARTS AND ACETYLENE GENERATORS.

are complete, and while installed primarily for demonstration are also used for lighting.

The interior of the car is finished with light drab walls and white ceiling, which taken in connection with the black demonstrating apparatus, gives a most pleasing interior appearance. It it carried on two six-wheel trucks, the one under the boiler, which carries the larger part of the weight, having 5 x 9 in. journals and the one under the office end having 4¼ x 8 in. journals.

THE TALLEST OFFICE BUILDING.—The Metropolitan Life Building at Madison Square, New York City, is having an annex or addition built to its present eleven-story building which will include a tower 658 feet high, having forty-eight stories in all. For the first eleven stories the addition covers an area of 153 x 75 ft. From this to a point 492 ft. above the ground the tower will be 75 x 85 ft. in plan. Above this a pyramidal structure will extend 94 ft. high, the whole to be surmounted by an octagonal cupola 70 ft. high. The completed building will have a total floor area of 1,085,663 sq. ft., or about 25 acres.

THE RECESSION OF NIAGARA FALLS.—A pamphlet recently issued by the U. S. Geological Survey states that the rate of recession of the Horseshoe fall, or the rate of lengthening of the Niagara gorge, during the 63 years from 1842 to 1905 is found to be 5 ft. per annum, with an uncertainty of 1 ft. For the 33 years from 1842 to 1875 the rate was apparently slower than for the 30 years from 1875 to 1905. The rate of recession of the American Fall during the 78 years from 1827 to 1905 was less than 3 inches per annum. The present and prospective diversions of water for economic uses interfere with the course of nature and may be expected to modify the future rate of recession.

PRESENT REPAIR SHOP REQUIREMENTS.—A man who formerly took a small engine into the shop once in two years and gave it an overhauling in two months must now, in order to play even, take twice as heavy an engine into the shop once a year and do twice the work in 30 days. If in addition he is to do better than he formerly did, if he is to improve as much as the engine in capacity, he must repair it in 15 days, therefore do twice the work twice as often in one-quarter the time. This is not an impossible task, since some shops are doing it, but they are exceptions.—*Harrington Emerson in the Railway Age.*

TONNAGE RATING.*

BY F. W. THOMAS.

In each step in the advancement of the size and hauling power of locomotives each new engine is expected to do a great deal more than its immediate predecessor, often a great deal more than it can do, and generally the traveling engineer has to explain why it would not do better. In every endeavor to make these engines haul what was expected of them we have gradually increased the load, increased the time over the division and decreased the speed until it is a rare thing that we see a freight train moving faster than seven miles an hour over the controlling grades, where they formerly made as high as fifteen to twenty.

On account of the increase in salaries of our officers, the increase in pay for the men who run the engines, the increase in the cost of material and the increase in interest charges, it has been necessary to take advantage of every opportunity offered to see that each engine is given all it can pull over the division and yet at the same time keep the traffic moving.

The methods of rating engines are as various as the roads in the country. Each road appears to have a method of its own, and the writer will only give the methods with which he is familiar, leaving it for each of you to discuss this subject and your own method of rating engines.

The method used by the Santa Fe System in rating engines is first to ascertain the theoretical rating; after this has been done, a

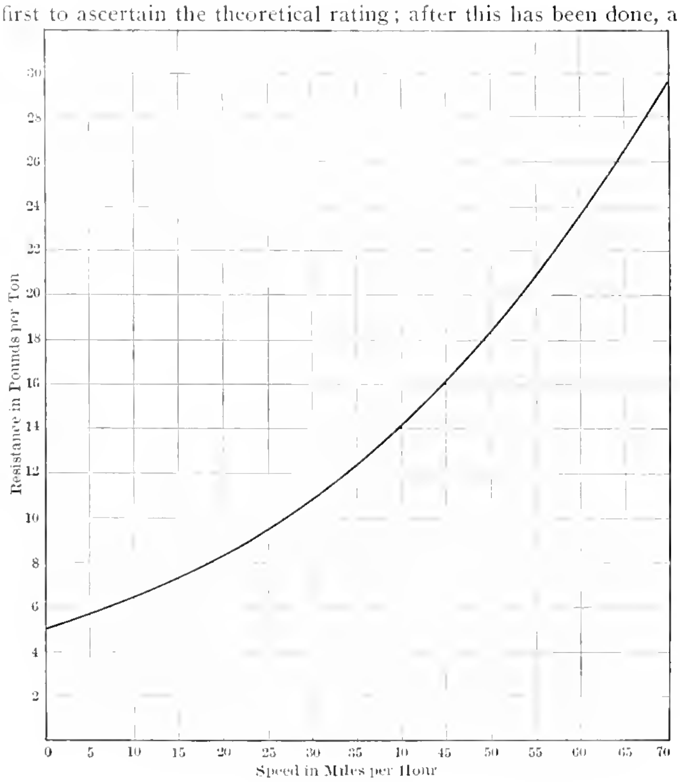


FIG. 1.

representative of the test department in company with the traveling engineer and train master will prove this rating by actual test, using engines of different classes. After the practical test has been made and any or all errors corrected for the class tested, the remaining classes of engines on the district are pro-rated according to their tractive power.

The most difficult problem after the rating has been ascertained and proven, is to express the rating intelligently and in such a form that the dispatchers, yard masters, foremen or switch crews and conductors can understand and easily interpret the rating sheets.

The most difficult thing to impress upon those interested is the fact that the rating is often governed by the number of cars in the train; the greater the number of cars, the greater the rolling resistance. In the eyes of the average train master and dispatcher a thousand tons, whether confined in twenty cars or in fifty, is a thousand tons.

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* From a paper presented at the fourteenth annual convention of the Traveling Engineers' Association, 1906.

The train master in his daily report shows the tonnage of each train handled over his territory and on the same report he must show the maximum tonnage rating. The earlier rating sheets only show two ratings, one for loads and one for empties. It has been our object to prepare a sheet which will show the correct rating for engines, whether heavy or light loads, or whether all loads or all empties. The rating given for a certain number of cars will be the maximum rating for the engine for the given number of cars.

Figure 1 is a curve showing rolling or frictional resistance in pounds per ton for speeds. Figure 2 shows decrease in tractive power with increase in speed. Figure 3 shows methods of expressing tonnage rating, a booklet for each division, and a page for different tonnage districts.

Referring to Figure 3, this rating is shown for cars weighing fifty tons down to cars weighing sixteen tons. By using this rating sheet the train master in his daily report shows that his train came in with so many cars and certain tonnage; by referring to the rating sheet it will show what the rating should have been for that number of cars, and this rating will be the maximum rating for that engine. You will note on the same chart that the maximum rating is shown in cars weighing fifty tons, and for every car added to the train above this given number of cars a reduction from the maximum rating must be made of from four to five tons. The four-ton reduction is generally made on a division where the track is generally straight and the five-ton reduction is made on a division where the curves are more pronounced and where prevailing winds are encountered. I cannot say that this reduction is based on any fixed rule, beyond, as

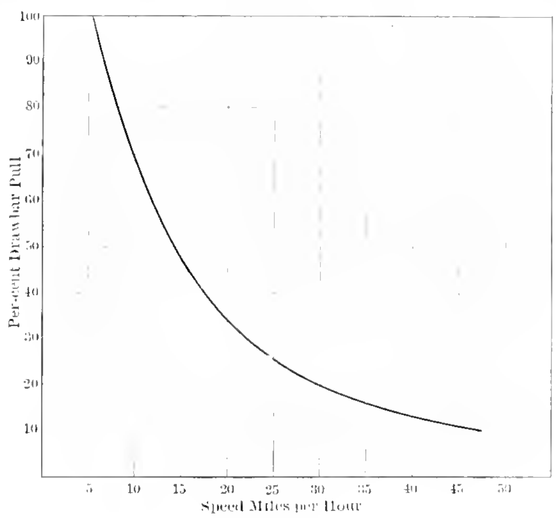


FIG. 2.

mentioned above, that it is the fruit of long investigation and a series of tests, and is often controlled by local conditions.

We have found in each case where the rating is so made and shown, if lived up to, there is a great deal of the disagreeable taste resulting from this tonnage rating business, eliminated. We find that an engine can pull its rating in sixteen-ton cars as easily as it can pull its rating in fifty-ton cars, and this is one of the secrets of properly rating engines.

As a basis for calculating the maximum rating we start out with a resistance of five pounds per ton rolling or frictional resistance, twenty pounds per ton for each per cent. of grade, and one-half pound resistance for each degree of curvature, where the curves are compensated for forty-five miles per hour speed. Now for the minimum rating we allow the same for grades and for curvature as with the maximum, but for the rolling resistance we allow 8.5 to 10 pounds per ton, so with an engine of 40,000 pounds tractive power, weighing 160 tons, we find on a one per cent. grade that it could pull 1,270 tons. The analysis of the total resistance is five pounds per ton for frictional resistance, twenty pounds per ton for grade, and where the maximum curve is six degrees we would have three pounds for curvature, giving a total resistance of twenty-eight pounds per ton. This into the tractive power gives a total tonnage of 1,430, and subtracting the gross weight of the engine and tender in working order, 160 tons, we will have 1,270 tons, the maximum hauling capacity of the engine with fifty-ton cars. Now with empties, or sixteen and two-third-ton cars, we have a tonnage of 1,110. The minimum rating of 1,110 for sixty-four cars will be a difference of 160 tons, so the rating for this engine should be shown in the following manner: 1,270 tons in twenty-five cars; 1,262 tons in twenty-eight cars, 1,246 tons in thirty-two cars, and so down to 1,110 in sixty-four cars. This formula is for the maximum power of the engine at a speed of from five to seven miles an hour on the hardest pulls. Should it be desirable to run at a faster speed than this, you must first establish the maximum speed at which you wish to move, that is over the controlling grade, and in addition to the resistance mentioned above you should add to it the resistance due to increased velocity, as shown on the curve No. 1. The above figures are for favorable conditions—favorable as to condition of engine and favorable weather.

Another factor entering into the resistance column, very often the controlling one, is the wind resistance. This factor, I regret to state, has not been satisfactorily adjusted anywhere, although we all know that a quarter wind offers the greatest resistance. Still on account of the variety of cars composing the average freight train it is impossible to fix any set percentage of reduction.

Another factor which enters the resistance column is the tem-

WESTERN DIVISION INDEX

1st District	Page 1, 2, 3, 4
2nd District	" 5,
3rd District	" 6, 8
4th District	" 6, 7, 8
Great Bend District	" 9
Larned District	" 10

The weight of train should never exceed the tonnage opposite the number of cars. Caboose counted as one car, 18 tons.

WESTERN DIVISION 7

Tonnage District	No. of Cars	Class of Engine: 151 221 261	283 315 317 354	507	468	1050	1200	825			
		TONS									
Caddoa to Hilton	19	950	(21)	(22)	....	....	....	....	....	....	....
	20	946	1050	1100	....	....	....	....	....	....	....
	24	930	1046	1092	(29)		....	....	....	....	..
	28	914	1030	1076	1450	(34)	1500	....	....	....	....
	32	896	1014	1060	1438	1700	1492	....	....	....	....
	36	876	996	1044	1422	1692	1476	....	....	....	....
	40	856	976	1026	1404	1676	1460	2000	....	....	....
	44	831	959	1008	1384	1658	1440	1984	....	....	....
	48	816	931	988	1365	1640	1420	1968	....	....	...
	52	(49)	916	968	1345	1620	1400	1950	...	....	...
	56	....	(55)	948	1325	1600	1375	1942	....	...	...
	60	....	....	(57)	1300	1575	1350	1922	...	....	...
	64	....	....	....	1275	1550	1325	1900	....	....	...
	68	....	....	....	1250	1525	1300	1875	....	....	...
	70	....	....	....	1225	1500	1275	1850	....	....	...
	..	....	....	....	....	....	....	....	....	....	....
	..	....	....	....	....	....	....	....	....	....	....

FIG. 3.

perature. In the extreme southern section of the country where the temperature is even throughout the entire year or never below the freezing point, it is not necessary to take into consideration the temperature, but in the colder climates where the prevailing temperature in winter is below the freezing point we find it is necessary to make considerable reduction. It is a custom of the Western roads and some of the divisions on the Santa Fe System, to make a reduction of ten per cent. between the months of November and April under favorable winter conditions. But it has been our experience for a frosty or wet rail to make a seven per cent. reduction, from thirty-two degrees down to zero Fahrenheit make a ten per cent. reduction, and from zero below to make a twenty per cent. reduction.

In addition to this we have another reduction which the writer thinks should be made, but at the same time it is a very delicate question, namely, the reductions on account of the condition of

the engine. We feel sure that were any road to simply make a reduction on the condition of the engine, there would be a continual warfare between the mechanical and transportation departments, unless the condition be based on the mileage the engine makes and allowance for the time the engine has been out of the shop; nor are we aware of any road that allows any reduction to be made on account of the condition of the engine. We do believe, however, that the reductions should be made for the condition of the engine, that is, the master mechanic and traveling engineer should say what is the condition of the engine, and each engine should be placed under a certain class or number of condition rather than the time that it has been out of the shop. I would say the engines should be divided into three classes. If an engine is in good condition and good for maximum tonnage, we will call it A class; when it reaches a certain condition a reduction of ten per cent. should be made and we will call this class B, and then the third class with a twenty per cent. reduction, which we will call C. After this the engine should go to the shop, for it does not pay any road to keep an engine in service if it is necessary to reduce the tonnage below 20 per cent. of the regular rating.

Until the roads adopt or the officials stamp their approval upon a scheme of this nature, tonnage rating will continue to have a disagreeable drawback.

Recent tests which the writer has made with cars equipped with ball or roller center and side bearings, proved that with the modern roller or ball bearing an increase of about seven per cent. tonnage can be hauled over divisions having a number of curves; in other words, on a six-degree curve the engine could start fully 100 tons more in cars having roller bearings than in cars having ordinary slide bearings.

While in motion, a train moving eight or nine miles an hour on a tangent with the common slide bearing the speed of the train would reduce from one and one-half to two miles an hour when pulling around curves; with roller bearings the speed would be reduced only three-fourths to one mile an hour. This slight increase of speed would allow the train with the roller bearings to attain a higher speed on a straight track, pick up speed on short tangents, and approach the next curve with a greater momentum.

We all are aware that there are very few trains of the same number of cars and the same weight which will pull alike. The writer, when making some tonnage tests on mountain divisions, got along nicely with the maximum theoretical tonnage with one set of cars; but on the second trip with the same weather conditions, same engine, same number and class of cars, and with fifty tons less tonnage, actually stalled and was unable to pull the tonnage over the same territory.

We have always been able to pull nearer the maximum tonnage with compound engines than with the simple engines. It is our custom to give simple engines a lighter rating than compound engines.

With the simple engines when they stall it is a matter of doubling the hill; with the compound engines we always have the "Big Gun" or the simpling lever to fall back upon to tide us over the critical point.

There is one point in reference to tonnage rating that I wish to dwell on for a moment; it does not particularly injure an engine to pull its tonnage, although it is a little harder on the cylinder and frame to work at full capacity. At a speed of six to seven miles an hour it is not as hard as it is when running at a higher speed, for more power is developed at a higher speed (evaporation is greater, fuel consumption per hour is greater) than will be developed at seven miles an hour. The engine will burn more coal per hour when running at fifteen miles per hour than when running at seven miles an hour. It is true the total consumption over a division is greater on account of being on the road longer; but what does the injury is to have the engine out for such long hours—the engine crew become worn out, the water in the boiler becomes foul, the fire-box becomes dirty, causing an irregular steam pressure, resulting in leaky flues, etc. This one thing is more harmful to an engine than the fact that it is pulling heavy tonnage.

We advocate that where the division is 100 to 110 miles in length the full rating should be given the engine; but where the division is longer the rating should be decreased in consideration of the length of the division. Not a decrease proportionally, but decreased sufficiently in order that the total time over the division should be reasonably close to the time over the division 100 to 110 miles in length with full tonnage.

The full engine rating can be hauled cheaper on a double track than it can be hauled on a single track. For where there is a road with sufficient business to move their engines on a tonnage rating basis there are always sufficient trains to cause considerable delays. However, a good deal of the expense of pulling in and out of sidings is eliminated by roads having two or more tracks.

We do think that on roads where traffic is sufficiently heavy to cause twenty-five to fifty per cent. delays in taking siding and getting orders, fully ten per cent. reduction from the maximum rating should be made. Such reductions would enable the engine to make faster time betwen stations and consequently shorten the time that it would be on the road. We believe also that over divisions where the grades are undulated the engine should be loaded nearer the maximum rating than over those divisions where the controlling grades are ten, fifteen and more miles in length.

On the undulated grades where the maximum pull is only three to four miles in length the momentum will enable you to cover the first mile in good time, and leave you only two or three miles to be gone over with drag speed. Whereas over the divisions where the grades are longer sufficient reductions should be made to enable the engine to go up these grades at a faster speed than the speed which it would otherwise make with the maximum rating.

Higher Cutting Speed with an Intermittent Cut.—An intermittent cut has a very different effect upon cutting speed from that produced by chatter. We have observed in a large number of cases that when a tool is used in cutting steel with a heavy stream of water on it (and this is the proper method of cutting steel of all qualities), a rather higher cutting speed can be used with an intermittent cut than with a steady one. The reason for this is that during that portion of the time when the tool is not cutting, the water runs directly on those portions of the lip surface and cutting edge of the tool which do the work, and for this reason the tool is more effectively cooled with intermittent work than with steady work. As an example of intermittent work, the writer would cite:

a Cutting the outside diameter of a steel gear wheel casting, in which case the tool is only one-half its time under cut.

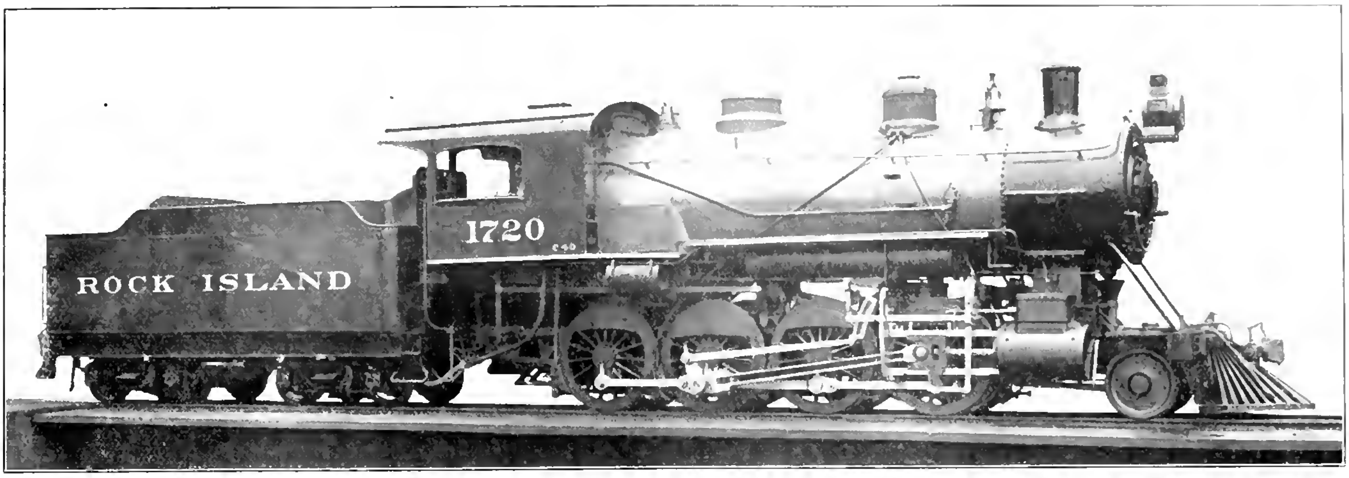
b. Or turning small pieces of metal which are greatly eccentric.

c. Or, for example, all planer and shaper work which is not too long.

It would seem from a theoretical standpoint that a tool would be greatly damaged (and therefore a slow cutting speed would be called for) by the constant series of blows which its cutting edge receives through intermittent work. It will be remembered, however, that in planer work (and this class of intermittent work comes to the direct attention of every machinist) the tool is more frequently injured while dragging backward on the reverse stroke of the planer than it is while cutting, and it is very seldom that a tool is damaged as it starts to cut on its forward stroke. In all cases, however, where the tool deflects very greatly, when it starts its cut on intermittent work slower speeds are called for than would be required for steady work.

The above remarks on intermittent work do not of course apply to cast iron with a hard scale or the surface of which is gritty. It is evident that in all such cases owing to the abrasive action of the sand or scale on the tool, intermittent work is much more severe upon the tool than a steady cut.—*Mr. Fred W. Taylor, before the Am. Soc. Mech. Engrs.*

Pension Fund Increased.—The annual appropriation of the Pennsylvania Railroad to its pension fund for retired employees has been increased from $390,000 to $600,000. There are now 1,040 men on the pension rolls of the company.



SIMPLE CONSOLIDATION LOCOMOTIVE WITH WALSCHAERT VALVE GEAR—CHICAGO, ROCK ISLAND & PACIFIC RAILWAY.

SIMPLE CONSOLIDATION LOCOMOTIVE.

CHICAGO, ROCK ISLAND & PACIFIC RY.

The Baldwin Locomotive Works recently completed the delivery of an order of 83 large consolidation locomotives for the Chicago, Rock Island and Pacific Ry. These locomotives have large, simple cylinders, large drivers and a boiler pressure of 185 lbs. and indicate the recent tendency of building very powerful freight locomotives with comparatively large drivers to handle heavy trains at higher speeds than was previously considered economical. The low boiler pressure is in keeping with the results obtained by Dr. Goss in his experiments* and has been standard on the Rock Island for all types of locomotives except the Pacific, for several years. The boiler in this case is designed for 200 lbs. pressure and that pressure can be used in certain districts where a larger boiler capacity may be needed.

Balanced slide valves operated by a Walschaert valve gear are used. The center lines of the steam chests are 3½ inches inside the center of the cylinders, which necessitated the use of a rock shaft to transfer the motion from the plane of the valve gear which, of course, is outside the center line of the cylinders. This rocker arm is supported on a frame cross brace just back of the cylinders and has both arms extending downward. The outer arm connects directly to the top of the combination lever and the inner arm drives the valve stem through a crosshead connection, the valve stem being guided by a bracket supported on the top guide bar.

The frames are of cast steel, with double front rails, and measure 5 inches wide throughout. The equalization system is broken between the second and third pair of driving wheels. The loads on the third and fourth pairs of wheels are equalized through beams placed over the boxes, with an inverted leaf spring between, and coil springs front and back.

The boiler is of the extended wagon top type with a radially stayed firebox. The mud ring is 5 inches wide on all sides and the water space rapidly increases in width toward the crown sheet. The outer side sheet is vertical while the firebox side sheet slopes inward. The back head and throat sheet are sloping, the throat being rather shallow. The heating surfaces and boiler ratios are given in the accompanying table.

The tender has a steel frame and capacity for 7,000 gals. of water and 12 tons of coal.

The general dimensions are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Frgt.
Fuel	Bit. Coal
Tractive effort	39,500 lbs.
Weight in working order	198,600 lbs.
Weight on drivers	177,300 lbs.
Weight on leading truck	21,300 lbs.
Weight of engine and tender in working order	238,900 lbs.
Wheel base, driving	17 ft.
Wheel base, total	26 ft.
Wheel base, engine and tender	58 ft.

* See AMERICAN ENGINEER, January, 1907, p. 13.

RATIOS.

Weight on drivers ÷ tractive effort	4.5
Total weight ÷ tractive effort	5
Tractive effort × diam. drivers ÷ heating surface	960
Total heating surface ÷ grate area	5.2
Firebox heating surface ÷ total heating surface, per cent	6.5
Weight on drivers ÷ total heating surface	67
Total weight ÷ total heating surface	77
Volume both cylinders	14.4 cu. ft.
Total heating surface ÷ vol. cylinders	180
Grate area ÷ vol. cylinders	3.47

CYLINDERS.

Kind	Simple
Diameter and stroke	23 x 30

VALVES.

Kind	Bal. slide
Greatest travel	5½ in.
Gear, type	Walschaert

WHEELS.

Driving, diameter over tires	63 in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	36 in.
Engine truck journals	6 x 12 in.

BOILER.

Style	E. W. T.
Working pressure	185 lbs.
Outside diameter of first ring	74 in.
Firebox, length and width	107 x 67¼ in.
Firebox, water space	5 in.
Tubes, number and outside diameter	340-2 in.
Tubes, length	15 ft. 6 in.
Heating surface, tubes	2,427 sq. ft.
Heating surface, firebox	168 sq. ft.
Heating surface, total	2,595 sq. ft.
Grate area	50 sq. ft.
Smokestack, height above rail	15 ft. 7 in.
Center of boiler above rail	9 ft. 9 in.

TENDER.

Frame	Steel
Weight, light	58,000 lbs.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,000 gals.
Coal capacity	12 tons

THE CARD INDEX—ITS ADVANTAGES.—Briefly, the card index then has the following advantages:

Accessibility—always get-at-able—nothing is buried and lost.

Time-saving—for the searchers after information.

Expansibility—only one end, the beginning. Can enlarge forever and still be as good.

Order—new material inserted into exactly the proper place.

Adaptability—suits every frame of mind, and every sort of business; varied classification.

System—encourages system in vast accumulating data and brings it under general heads of classification.

Divisibility—some cards can be removed for temporary use elsewhere, or for permanent transfer.

Labor-saving—nothing has to be rewritten, saves clerical labor.

Simplicity—can be operated by the inexperienced.

Contractibility—no need of retaining useless, outgrown matter.

No wasting of spaces—it is impossible to apportion blank spaces in books so that they will fill evenly.

Always being up to date.

Rearrangement made easy.

Substitute for memory—supplementing it and becoming independent of existing hired memories.

Classifications within the index—by using tab cards.—*Prof. H. Wade Hibbard.*

PRACTICAL MEANS FOR INCREASING THE EARNING CAPACITY OF FREIGHT CARS.*

By J. E. Muhlfeld.†

Design and Construction.—Compact train loads increase and accelerate movement, by reducing the cost for switching and transporting traffic. Therefore, in the design and construction of a freight car it is advisable to arrange for the maximum volume and weight of lading per lineal foot of track space and for the quick loading and unloading of the greatest variety of commodities.

While convertible features should not be embodied in equipment to an extent that would result in extraordinary first or maintenance cost, a limited number of practical arrangements, such as movable floors, ends and sides may be combined to provide a car suitable to carry and dump lading such as coal, ore, dolomite, sand and similar material into manufacturing plants and to be loaded with billets, pig iron, pipe, plate, structural steel and other commodities, thereby enabling it to carry freight both coming and going, thus reducing the light car mileage to a minimum.

Wood should be used in freight car construction only where it is required to provide for the cleating and otherwise bracing and building up of certain classes of lading and where metal would not insure the proper insulation against heat or cold.

Steel plates for horizontal flooring should be made of sufficient thickness to prevent early depreciation due to corrosion, while inclined and vertical sheets can be made thinner, if well braced. Unnecessary joints and rivets should be eliminated and such a combination of flat and formed plates and structural shapes should be used in the construction as will provide the proper strength with the least amount of material used and enable the most economical maintenance on account of ordinary wear or tear and casualty.

Formed or cast steel sections built into the underframe as a body bolster and structural or cast steel truck bolsters and side frames can be combined to make a light and strong construction. The increasing severity of buffing and pulling stresses makes it necessary to materially strengthen the center sills by deep box designs and to distribute these shocks over a large area of the draft and center sills in a manner that will relieve all other parts of the under and superimposed frame of the car body from stresses that will tend to loosen the rivets and joints.

Of the various items contributing to freight car delays and failures, the couplers, coupler yokes, draft gear and attachment of same to the underframes, body and truck bolsters and the wheels and brake equipment contribute either directly or indirectly to the greatest extent. A combination of coupler, coupler yoke and draft gear of sufficient strength and elasticity to withstand the locomotive maximum draw bar pull and the punishment due to buffing shocks will, when securely attached along the center line of draft to the center sills in such a manner as to distribute the stresses at the greatest number of points and over the largest area, materially reduce the coupling difficulties.

The use of substantial body and truck bolsters that will carry the ultimate load at the center plate; of anti-frictional center plates and side bearings, and of ample lateral movement for couplers at the end sills will do much to reduce train resistance, wheel flange wear and liability for derailment. However, so long as the rail section now generally in use is continued it will be difficult to prevent rapid wheel flange wear and possibility of breakage, but a refined chilled cast iron or a one-mileage forged steel wheel with hardened flange and tread wearing surfaces would be of general benefit, if produced at a reasonable cost.

The necessity for the use of hand brakes in the controlling of freight trains on long and severe grades at speeds that will provide for the movement of the maximum business with a proper degree of safety, frequently determines the tonnage of trains both up and down grade, and a combination of air and foundation brakes, brake beam and shoe, and slack adjusting equipment that will insure maximum allowable braking power per car and place the entire control in the hands of the locomotive engineer without liability for sliding wheels, will be of material assistance in increasing the capacity of railroad lines traversing a mountainous section.

Interchangeability of Parts.—While the Master Car Builders' Association has made much progress in promulgating general practices and adopting standards of minor parts of cars, such as—wheels, axles, journal boxes and contained parts; brake beams, heads and shoes; couplers; hose; side and end doors; helical springs; foundation brake gear; safety appliances and marking—the changed conditions now make it essential that car bodies and trucks as a whole, of similar kinds and classes, shall be simplified by standard practice and made interchangeable, and it is anticipated that some final action along these lines will result from the coming meeting.

Maintenance.—The freight car of today must withstand about as much grief as the average mechanical department official. It is required to operate on 60 degree commercial track curves and over any obstacle; to withstand a 25-mile per hour impact when loaded and passing through gravity and hump yards; to be mauled and turned upside-down for dumping; to receive red-hot lading, such as billets, pig iron and slag; to resist the steam, fire and dynamite that is used to loosen frozen loads of coal, sand and ore; to submit to the corrosive action of acids, alkalis, water and weather; to retain any load that can be safely gotten into or on top of it; to endure loading by crane hoist; undergo removal of lading by clam shell, scraper or plow; to be able to lose any part of itself that may facilitate loading or unloading and to still retain its identity and return to its owners with a clear record against delay, failure or personal injury.

Therefore, it becomes necessary that the maintenance of this equipment be given adequate attention to insure it against the general operating causes for failure which consist of unsuitable distribution and use of cars that are adapted for only certain classes of commodities and service; freight improperly distributed or built up; lading beyond the allowable capacity for distributed or concentrated weight; abuse by consignors and consignees when loading and unloading; cars of light capacity and design placed at the head end of and between cars of heavier types in trains; and rough handling by yard, train and engine crews.

The number of loaded and empty system and foreign revenue freight cars (exclusive of cars in bad order condition under load at destination), held over each day (except after Sundays and legal holidays), for all classes of accident and ordinary repairs, should not exceed 3 per cent. of the total system and foreign revenue cars on the line and the repair force and material should be so regulated that no more bad order cars will be detained each day than the number repaired, every preference being given to loaded and empty cars that are in the greatest demand for the movement of the business offered.

When the earning capacity averages from $2.50 to $3.00 per day for each freight car available for service, the interest on an investment for shop facilities to adequately economize and increase the output can be readily justified. Such facilities should provide shelter from sun, rain, snow and wind for workmen employed on cars requiring heavy repairs, so that the usual increase in the proportion of bad order cars after unfavorable weather conditions will not be so marked as at present. Ample and up-to-date metal and wood working machine tools, pneumatically or electrically operated portable and hand tools and general facilities for the storage and portage of all new, second-hand and scrap material are most essential. Transfer trestles and cranes should also be installed in freight car repair yards to reduce switching, delay and expense for transferring and rebuilding lading on cars which are not in condition for movement.

Indifferent foreign cars should be put in proper repair for loading and not returned to the owners light except when generally worn out by age and decay, or unless lading is not available and a home station is close by. This practice will avoid loss due to light mileage and additional damage to the car through its movement in a defective condition.

The prompt and proper switching of cars on repair tracks is an

* Extract from a paper presented before the March meeting of the Railway Club of Pittsburgh.

† General Superintendent of Motive Power, Baltimore & Ohio Railroad.

operation that is frequently overlooked and which is usually given indifferent attention and is done at whatever time the yard switching service may find it convenient, rather than during a period when it will least interfere with the working of the forces. Many unnecessary and costly movements can be avoided by the spacing of cars when they are switched on the shop tracks so as to eliminate the delay and expense that would otherwise occur by jacking the cars apart and moving them by hand.

Certain classes of cars should be given special repair attention at those seasons of the year when the business least requires their use or when the repair forces can be worked to good advantage during daylight and favorable weather. System cars of a class and capacity which makes them desirable for five or more years' service, should, when empty and placed on shop tracks for heavy repairs, receive such renewals and betterments as will put them in a substantial condition. The repetition of classified repairs which do not permanently improve such equipment results in temporary maintenance, successive line failures and delays to traffic, and continued expense for the same class of work. Good material removed from cars that should receive heavy repairs and betterments to put them in efficient condition, can always be utilized to advantage when making lighter classes of repairs to loaded and empty cars to keep them temporarily serviceable until they can be properly reinforced.

Terminal and Interchange Inspection.—The object of the Master Car Builders' Rules is to facilitate the movement of cars in interchange service and to place the responsibility for defects which may or may not make a loaded or empty car unfit for service. However, the intent of the rules is frequently nullified through a lack of good judgment owing to the somewhat general impression that the ability of a car inspector is decided by his record as a "car stopper" rather than as a "car mover," and the holding of cars by unintelligent inspection or on technicalities at joint and interchange points, is responsible for much delay to traffic, expense for transferring lading and loss of use of equipment.

Cars set off on the line of road due to bad order condition of couplers, draft attachments, wheels or brakes; heated bearings; shifted lading and other similar causes are usually the outcome of improper inspection, repairs, adjustment or testing of brakes, lubrication and loading at originating terminals, and result in accidents, destroyed lading and cars, reduced train rating, delays to traffic, blocking of passing sidings, engine and train crew overtime and extraordinary expense for sending men and material out on the line to make repairs. The elimination of rules and inspection points which are unnecessary to maintain cars en route in a serviceable condition for operation and safe for trainmen and lading; fewer and more thoroughly trained car inspectors; agreements between connecting lines that will keep cars moving on such interchange records as will insure proper accounting for repair charges; a greater number of more competent car repairmen and more thorough attention given to equipment at the unloading and loading points will, without a doubt, reduce some of the present line delays.

The substantial building up and proper distribution of freight on single, twin and triple cars by shippers is also a detail that will do much to reduce delays to their freight between origination and destination points by eliminating the necessity for rebuilding and transferring lading or for setting out cars en route for consequential repairs due to derailments, heated bearings and similar causes.

Dismantling.—For the benefit of connecting railroads handling either interstate or intrastate traffic it is essential when a freight car of undesirable class and capacity has outlived its usefulness and reaches a shop track in such bad order due to age, decay and corrosion that the expenditure necessary to put it in serviceable condition is not justified, that it should be disposed of by dismantling rather than by sale, to insure its identity being absolutely destroyed.

Each car to be disposed of should be properly passed upon at the time that it condemns itself, rather than as a part of a general dismantling program at some predetermined period.

There is always some good material in a wooden freight car body, such as lumber, rods, bars, castings, bolts and nuts which can be utilized to advantage in repairing other cars, and the trucks, either wholly or in part, can invariably be disposed of by use under other equipment. Therefore, the destroying of cars by burning is only warranted in cases of extreme damage by accident on the line of road.

ELECTRICAL NIGHT AT THE NEW YORK RAILROAD CLUB.

The third annual electrical night of the New York Railroad Club was held on March 15th in the Engineering Societies Building. As previously announced, there was no regular technical paper presented, the meeting consisting of a series of short papers presented by electrical experts, who had been invited to speak. The subjects chosen were all to be on different phases of heavy electric traction.

The first paper was presented by Mr. W. J. Wilgus, vice-president of the New York Central Railroad, and was concerned very largely with matters in connection with the recent wreck of an electric train on that road. Mr. Wilgus stated that in view of the gross exaggerations and unjust attacks which had been made in the daily papers, and even in some of the technical papers, it would probably be of interest to discuss the actual facts of the case. He mentioned the fact that one of the electric locomotives had been given a 2½ years' test, running over 50,000 miles, on a six-mile stretch of track near Schenectady, before any of the locomotives were put in actual service. During this series of tests the locomotive had been operated at very high speeds on sharp curves without derailment or injury to the track. There had also been a series of preliminary runs made over the line on which the wreck occurred, with full weight trains, previous to the starting of the regular service.

In answer to some criticisms which had been made with reference to the use of the third rail instead of overhead construction, Mr. Wilgus pointed out that there were three reasons why overhead construction was impractical in the electric zone. One of these was that there is a clearance of but 2 in. in the Park avenue tunnel. Another was that a legislative act prohibits any additions in the way of overhead construction on the Park avenue viaduct, and the third, and most important, was the fact that the City of New York absolutely forbids the use of overhead current collection at high voltage.

The second paper presented was by Mr. George Gibbs, chief engineer of electric traction of the Pennsylvania, New York & Long Island Railroad, and gave some very interesting figures on the cost of heavy electric traction. He stated that he did not believe that engineers should be misled by the enthusiasm of the people for electricity. This paper was a most clear-cut discussion of the problem of electrifying steam railroads and will be presented in full in a future issue.

The third paper was presented by Mr. Walter C. Kerr, of Westinghouse, Church, Kerr & Co., who discussed the different methods that a steam railroad company could take in the physical work of electrifying a portion of their lines. He explained very clearly what features of advantage could be obtained by the employment of a firm of engineer-contractors whose personnel and resources could become part of the railroad company's organization for the time being.

Mr. Frank J. Sprague, who spoke next, went very carefully into the history of the electric locomotive on the New York Central Railroad, pointing out each step taken by the electric traction committee from the beginning. The point of particular interest mentioned by Mr. Sprague was the fact that bids for the locomotive equipment were received from one foreign and two American companies, the General Electric and the Westinghouse, and that the General Electric Company included in its bid a proposal for a single phase repulsion electric locomotive, but really recommended the direct current gearless locomotive. The Westinghouse Company, however, submitted no bid for alternating current locomotives, but recommended direct current locomotives of the geared type.

The next speaker was Mr. Theo. Varney, of the Westinghouse Electric and Manufacturing Company, who spoke on the devel

opment of catenary line construction. He was followed by Mr. W. B. Potter, chief engineer of the railway department of the General Electric Company, who gave some very interesting information in connection with the experiments his company is making with gasoline electric motor cars.

The last regular speaker was Mr. Samuel Vauclain, of the Baldwin Locomotive Works, who stated that he believed the designers of electric locomotives should make use of the large amount of information which had been obtained during the development of the steam locomotive. He considered the driving wheel diameter of the electric locomotive should be as large as for a steam locomotive for the same service. He stated that it had been his suggestion that the motors of the electric locomotive should be placed in about the same space and position now occupied by the boiler of a steam locomotive and that the drive should be through a system of rods and levers. The practicability of this system has been demonstrated by the electric locomotives used in the Simplon tunnel.

At the close of the meeting the president announced that the paper for the April meeting would be by Mr. W. R. McKeen, Jr., the subject being "Gasoline Motor Cars.

THE FAILURE OF LAP JOINTS.

To the Editor:

Some time ago, at a meeting of the Western Railway Club, a representative of the Hartford Boiler Insurance Company read a paper on the subject of boiler explosions. He gave as a cause of the giving way of nine-tenths of the exploded boilers, which he had examined in his capacity as inspector, the development of a hidden crack in the single lap joint, as shown in Fig. 1, the development of this crack being due to the bending moment induced by the tension in the plate which tended to shape the center line of the cross section of the joint to that of the arc of a circle, as indicated by Fig. 2.

This idea, though not entirely new, is no doubt a true explanation of the cause of failure of many longitudinal lap joints. There is another point of view, however, from which the weakness of the lap joint may be investigated.

When designing a joint of this type it is customary to determine the stress, per unit length, to which the plate will be subjected by the formula $f = \frac{Pr}{t}$ where f = the stress per square inch, P = the boiler pressure, r = half the diameter of the boiler shell, and t = the thickness of the plate. Such a calculation is very much in error and joints so designed possess no such factor of safety as the designer intended.

Taking a strip of metal of thickness t, and width z, subjected to a tension T, the fiber stress per square inch uniformly distributed over the cross section of the strip would be $f = \frac{T}{tz}$ when the center line of action of the stress passes through the center of section of the strip, as in Fig. 3. But when the strip is subjected to an eccentric pull, the center line of action passing to one side of the center of the section, the maximum unit stress is something very different.

Let Fig. 4 represent a strip subjected to an eccentric pull. The stress on each particle may be divided into two parts, the mean stress which is always the existing stress at the center of the section, and the variable part. The mean stress balances the force T; but the moment of T about the center, or $T \times y_0$, must be balanced by the moment of the variable part of the stress taken about the axis in the plane of, and through the center of, the cross-section perpendicular to y_0.

Let P = unit stress at the point distant y from the center measured in the direction y_0 and y_1, which latter is the distance to the edge = ½ t, where the unit stress is f. If P_0 = mean unit stress found at the center, $P - P_0$ will represent the variable part found at the distance y from the center.

$$\frac{P - P_0}{f - P_0} = \frac{y}{y_1}, \text{ or } P - P_0 = \frac{f - P_0}{y_1}\, y.$$

If z = width of section, the moment of the variable portion of the stress about the axis Z — Z (Fig. 5) through the center will be:

$$M = \int_{-y_1}^{y_1} \frac{f - P_0}{y_1}\, y\, Z\, d y\, y$$

$$= \frac{f - P_0}{y_1} Z \int_{-y_1}^{y_1} y^2\, d y$$

$$= \frac{f - P_0}{y_1} Iz$$

where Iz denotes the moment of inertia of the cross-sectional area about the axis Z — Z. This expression is the resisting moment of the cross section.

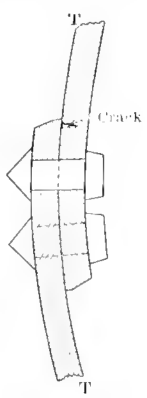


Fig. 1

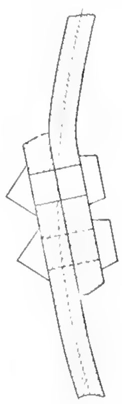


Fig. 2

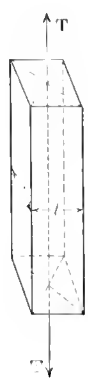


Fig. 3

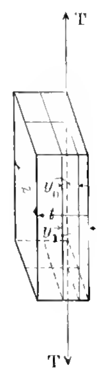


Fig. 4

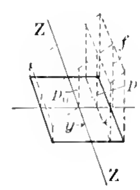


Fig. 5

But $M = T \times y_0$ and $P_0 = \frac{T}{S}$ where $S = t \times z$ or the area of cross section of the strip.

$$\text{Therefore } T \cdot y_0 = \left(f - \frac{T}{S}\right)\frac{Iz}{y_1}, \text{ or } T = \frac{f\,S}{1 + \frac{y_0\, y_1\, S}{Iz}}$$

$$= \frac{f\,S}{1 + \frac{y_0\, y_1}{r^2}}$$

where $r^2 = Iz \div S$ to be measured in the direction of y_1. Also

$$f = \frac{T}{S}\left(1 + \frac{y_0\, y_1}{r^2}\right) = \text{maximum unit stress due to T and } y_0.$$

Taking a circular strip of ½-in. plate 1 in. wide in a boiler 60 in. in diameter carrying 100 pounds pressure, the customary formula $f = \frac{Pr}{t}$ gives as the maximum fiber stress $\frac{100 \times 30}{½}$ = 6,000 pounds per square inch.

In the case of the lap joint the center line of action of the applied tension is at the surface of contact of the two plates, as at line T — T of Fig. 1. Applying the formula $f = \frac{T}{S}\left(1 + \frac{y_0 y_1}{r^2}\right)$ where $y_0 = y_1 = \frac{1}{4}''$ = half the thickness of plate, the maximum fiber stress is

$$f = \frac{100 \times 30}{\frac{1}{2}}\left(1 + \frac{1/16}{1/48}\right)$$

$$= \frac{100 \times 30}{\frac{1}{2}} \quad (1 + 3)$$

= 24,000 pounds.

This high stress on the extreme fiber may at first thought appear to be of no great importance since when subjected to a stress beyond the elastic limit the fiber of greatest stress would elongate there by throwing more of the stress upon those fibers in the direction of the other side of the plate. But it is an established fact that a material such as steel or iron, when subjected to a stress approaching the elastic limit, will resist such stress only a definite number of times, and when fracture does take place little or no elongation has been produced. An example of this is to be found in the breaking of axles due to the repeated tension and compression of the fiber as the axle rotates.

The actual fact that boiler plates do fail, as indicated by Fig. 1, in addition to the results as disclosed by mathematical investigation, would seem to indicate that the lap joint construction for a longitudinal boiler seam should never have been introduced in boiler practice.

In circumferential seams the conditions are not so serious since the stresses to be resisted are only half those in the longitudinal seams.

THEO. F. H. ZEALAND.

ILLINOIS CENTRAL, CHICAGO.

CLUB HOUSES FOR PANAMA CANAL EMPLOYEES.—Employees on the Panama Canal are being provided with club houses in most of the villages which the Canal Commission has built. They consist of a front building of two stories, connected with a rear building of one story. The former, which is 133 x 45 ft., contains a social parlor, a card room, a billiard and a writing room on the first floor, and an assembly hall 67 x 27 ft. on the second floor. The rear building, which is 100 x 28 ft., contains double bowling alleys 100 ft. long, a gymnasium 52 ft. long, shower baths and lockers. The Commission, in conjunction with the Y. M. C. A., will manage these buidings. Each club will select a board of directors from its own membership, but all clubs will be under the control of a general board selected by the Commission. A number of buildings are also to be erected for religious services, such buildings to be available for all denominations. In some places an additional story will be added to the latter buildings, to provide lodge rooms for the various orders and societies formed among the employees.—*Engineering Record.*

TIDINESS.—A few years ago a young man was given charge of a roundhouse at an out-of-the-way point on one of our large western railway lines. He was advanced from that position to the position of master mechanic, and took charge of one of the largest erecting shops on that line. In a very short time he was advanced from the position of master mechanic to assistant superintendent of motive power, and in a short time thereafter to superintendent of motive power. From that point he went east, and now holds one of the best positions in the mechanical line on any railroad in the United States. If I trace him further, I presume everyone here could mention his name. The keynote of his success was "tidiness." His roundhouse was kept clean and tidy, and as he was advanced, step by step, he did not neglect that which had called the attention of the officers of the road to him.—*Mr. J. H. Waterman before the Railway Storekeepers' Association.*

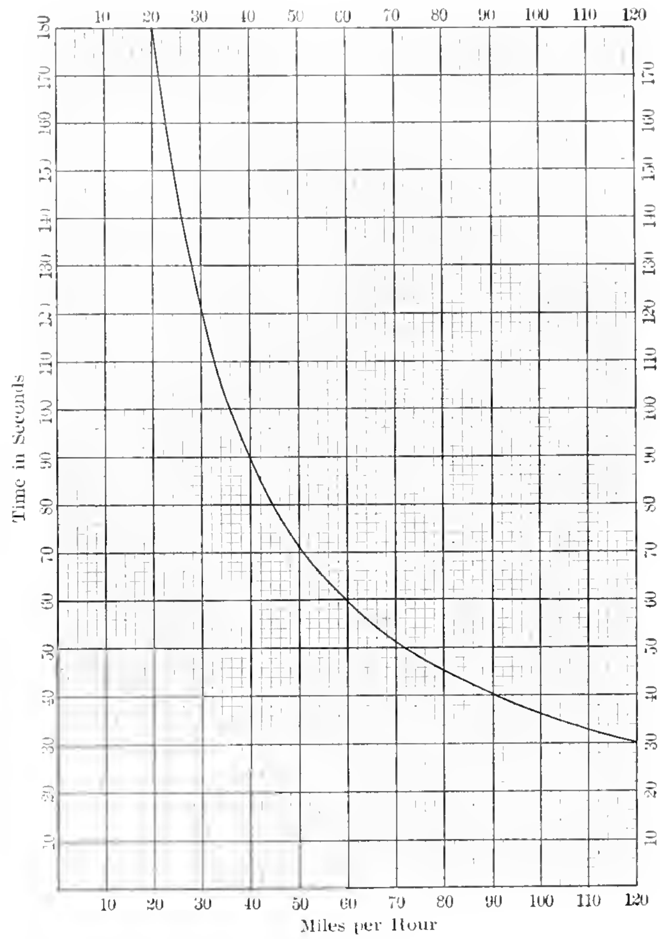
SPEED IN MILES PER HOUR

TO THE EDITOR:

Perhaps this may be new to you, perhaps not; but if it is, you will admit that it is a handy constant to store away in your memory for emergency uses.

Let speed in miles per hour be represented by "a"; time to run one mile in seconds at speed "a," by "b," and seconds in one hour by "c" then $\frac{c}{a} = b$; $c = 3{,}600$; therefore $\frac{3{,}600}{a} = b$, or $a \times b = 3{,}600$

In other words, the speed in miles per hour, multiplied by the



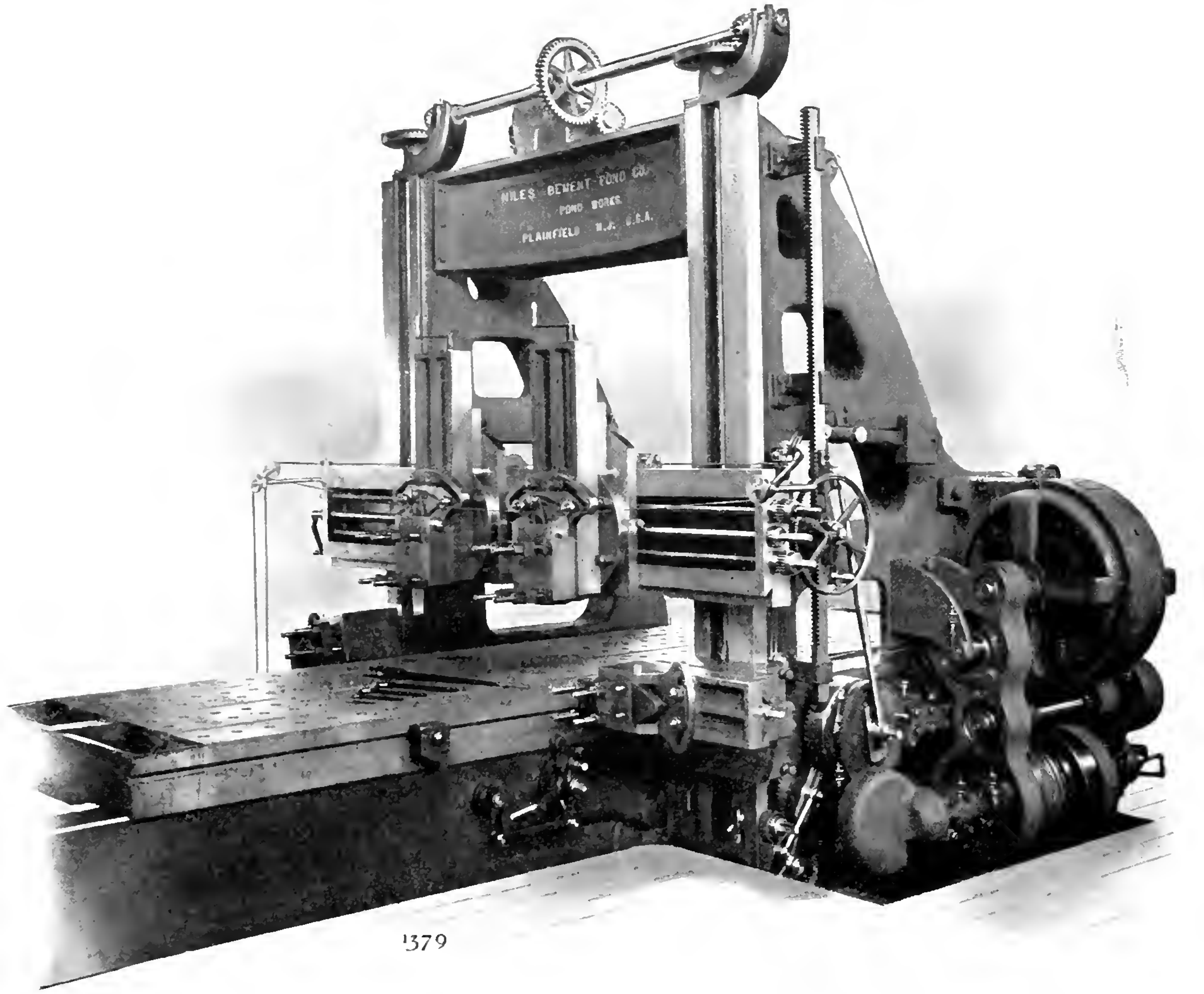
time required to run one mile at that speed in seconds, is always equal to 3,600.

The expression $a \times b = 3{,}600$ is similar to $a \times b$ = a constant, or the equation for the rectilinear hyperbolic curve representing the expansion line on an indicator diagram; and from this, the curve on the enclosed print was plotted.

W. O. MOODY,
Mechanical Engineer.

ILLINOIS CENTRAL RAILROAD, CHICAGO, ILL.

ELECTRIC TRACTION NOT PROFITABLE.—At the present time all the steam railroad companies that have adopted it (electric traction) are very much disappointed, suffering, as they are, considerably from the results as they have turned out as compared with the estimates given to them, and the information vouchsafed by those who were supposed to know. But every day now the cost of working electric traction is being reduced. We are not yet down to anything like the cost of steam traction, but, admittedly, it is an experimental time through which all railways, and especially the District and the Metropolitan and ourselves, are passing; and since we met last the actual cost has been considerably decreased, but we are not out of the woods yet.—*Chairman Stride of the Tilbury and Southend Ry., England.*



PNEUMATIC CLUTCH DRIVE APPLIED TO AN 84-INCH PLANER.

84 INCH PLANER WITH PNEUMATIC CLUTCHES.

The Niles-Bement-Pond Company are recommending the use of their pneumatic clutch drive on the larger size planers intended for heavy work. On such planers it is difficult to transmit sufficient power with the belt drive, since the width of the belts is limited because of the difficulty in shifting them. The pneumatic clutches will transmit any desired amount of power and it is possible to easily provide for various cutting speeds and a constant return speed.

The illustration shows one of these clutches applied to an 84 inch planer. The 55 h.p. General Electric motor is bolted to the housing and drives the clutch through gearing. If desired the clutch may be driven from an overhead counter by a wide non-shifting belt running constantly in one direction. If a constant speed motor is used variation in cutting speed may be obtained by change gears. The pneumatic clutch makes it possible to plane accurately to a given line. The diameter of the disk of the clutch shown in the illustration is 19 in.

An interesting account of the satisfactory service of one of these clutches under heavy duty was described in the March issue of the *Progress Reporter*. A 100,000 pound casting was planed on a 10 ft. Bement planer. The casting was too wide to pass between housings, and had to be finished with an extension tool clamped to one of the cross rail heads. The cutting speed was 28 feet per minute, and the return speed 78 feet per minute. The length of stroke was about 4½ feet for a period of five or six hours. The load together with table weighed 160,000 pounds.

The 84 inch planer planes 85 inches wide and 85 inches high. The table is 72 in. wide and is driven through a train of cut gearing and a rack. It may be stopped from either side of the planer without stopping the motor, and the reversing dog may be tripped, allowing the work to be run from under the tool for inspection. The bed is strengthened where the gearing and uprights are mounted, and is nearly twice the length of table. It has two V tracks, with large wearing surfaces and oil pockets with rollers for lubricating the table.

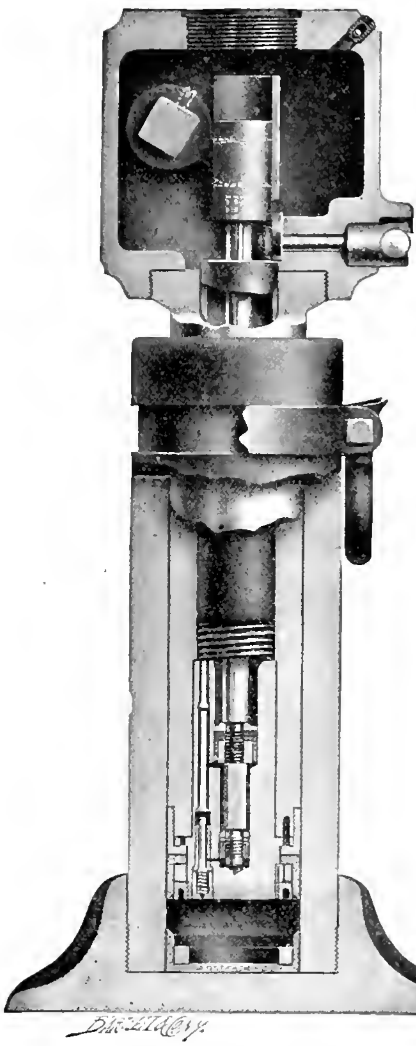
The uprights are fitted with counterbalanced, swiveling side heads with variable feed up and down the upright, driven directly by the driving gears instead of by friction. The crossrail of box form is raised by a 7½ h.p. motor; it has a deep-arched back, large wearing surfaces, taper packings for adjustment of the saddles, and sufficient length for one saddle to plane the entire width between the uprights without interfering with the other.

NECESSITY OF AMPLE REPAIR FACILITIES.—The management of the company is entirely convinced that nothing is more vital to the successful operation of a large railroad property than the provision of ample repair shop facilities, equipped with the most modern tools and labor-saving appliances for keeping in good repair locomotives and other equipment and instrumentalities required for efficient and economical operation.—*Annual Report of Pres. Truesdale, of the D. L. & W. R. R.*

SCHMIDT SUPERHEATERS.—There are at present 1,802 locomotives equipped with Schmidt superheaters in service or in course of construction. These are distributed over 60 different railways, principally in Europe.

DUDGEON UNIVERSAL HYDRAULIC JACK.

The first hydraulic jack was patented by Richard Dudgeon of New York City in 1851. The design was improved at various times, the latest and most important improvement being made in 1906. This last design, known as the "Universal," is shown in the accompanying illustration and is intended to meet the demand for a compact, light-weight hydraulic jack, easily handled, operated and controlled, and adapted to meet the requirements of the railroads for lifting heavy cars and locomotives. The method of actuating the piston rod, which passes down through the steel tube, is clearly indicated in the illustration. Under light loads the jack is operated by a double pump, which for a jack of 30 tons capacity will lift a load of 15 tons at the rate of 1 in. in every six strokes. Under heavier loads the lower



DUDGEON UNIVERSAL HYDRAULIC JACK.

pump only is used and will raise the jack at the rate of 1 in. for every 12 strokes.

The most important feature of the new design is that it requires only three valves, and they are all assembled in one chamber or passage, the two upper ones being suction valves and the lower one a pressure valve. The upper pump is cut out of action by the steel tube, which may be forced downward by the cam attached to the end of the shaft, which is operated by the handle at the lower right side of the head. When the valve handle is in the position shown, the spring just below the steel tube forces it up against the cam so that all of the valves are free to seat. When the valve handle is turned down to a vertical position the cam revolves sufficiently to force the tube downward until it comes in contact with the top of the valve stem and forces the upper valve off its seat. When in this position the liquid displaced by the upper piston simply surges back and forth through the valve. If the valve handle is turned 180 degrees from the position shown, the steel tube is forced downward far enough to unseat all three of the valves, allowing the ram to descend by its own weight. The jack may also be lowered by the lever, it being only necessary to depress the piston head until a pin projecting from the lower side of it encounters the top of the steel push tube, when it operates in the same manner as by the cam on the valve handle shaft. Any obstruction which prevents the seating of a valve can be removed by depressing the valve. If a valve should stick in its seat it can easily be pressed off. The interior parts are easy of access. The valves are reached by removing the ram and unscrewing the bonnet, when the valves with the removable seat will drop out. The piston packings are reached by unscrewing a plate in the head and lifting the piston through the opening. The jack may be operated either horizontally or vertically.

The form of base illustrated is recommended for railroad work, but a broader and heavier one can be furnished if desired. These jacks are made for various capacities, from 30 to 60 tons, by Richard Dudgeon, Broome and Columbia streets, New York City.

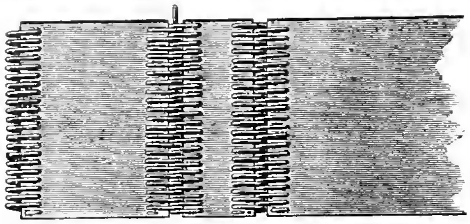
NEW TERMINAL AT HOBOKEN.—What is stated to be the most satisfactory ferry and train terminal upon the North River was formally opened on Feb. 23 by the Delaware, Lackawanna & Western Railway. The structure has a frontage of 730 ft. on the river and includes, in addition to the ferry house, six ferry slips and a fourteen track train shed, the latter being 607 ft. in length. This shed is built with a new design of umbrella type of roof, designed by Lincoln Bush, chief engineer of the railroad, and is generally admitted to be the most perfect example of this type of train shed ever constructed in this country. It consists of a series of spans supported by a row of columns in the centre of each platform, having a narrow opening over the centre of the tracks for the escape of locomotive smoke and gases; the remainder of the span being composed largely of glass, giving an exceedingly well ventilated, light and well protected train shed. The architectural features, both interior and exterior, throughout the whole terminal, are most attractive. The station is equipped with an emergency hospital, barber shop and bath rooms, as well as a large restaurant, offices and the usual waiting rooms, smoking rooms, baggage, express, etc.

TECHNICAL TRAINING IN ALTOONA HIGH SCHOOL.—Through the initiative of the Pennsylvania Railroad Co. a new development in industrial education is being tried out in the Altoona High School. The industrial department of the school has received, as a gift from the Pennsylvania, equipment that places it in this respect on a par with the foremost technical schools of the second class in the United States, and far in advance of many of them. A four-year course is planned which will afford in a public school opportunities for training that have been open heretofore only to students of the technical schools. The railroad expects to secure from the high school, candidates for its shops who will enter them on a footing between that of the regular and special apprentices. The city of Altoona secures a splendidly equipped industrial school, perfectly adapted to the needs of a population, a fourth of which is employed in railroad shops, yards and offices. Altogether the new high school will cost not far from $350,000.

TEN YEARS' INCREASE.—Compared with the official returns for 1896 the figures for 1906 show the following remarkable results: Miles of line increased, 20.0 per cent.; miles of track, 31.7 per cent.; number of locomotives, 42.6 per cent.; weight of locomotives, 82.8 per cent.; number of freight cars, 51.5 per cent.; weight of freight cars, 95.3 per cent.; passengers carried one mile, 88.6 per cent.; tons of freight carried one mile, 124.3 per cent.; cars with automatic couplers, 243.1 per cent.; cars with train brakes, 265.6 per cent.; gross earnings, 101.7 per cent.; expenses of operation, 98.2 per cent.; wages of employees, 94.3 per cent.; interest and dividends, 70.5 per cent.; taxes, 72.4 per cent. In the meantime the average receipts per passenger mile have decreased 0.4 per cent. and per freight ton mile 6.9 per cent. —*Slason Thompson in recent pamphlet.*

BELT LACING MACHINE.

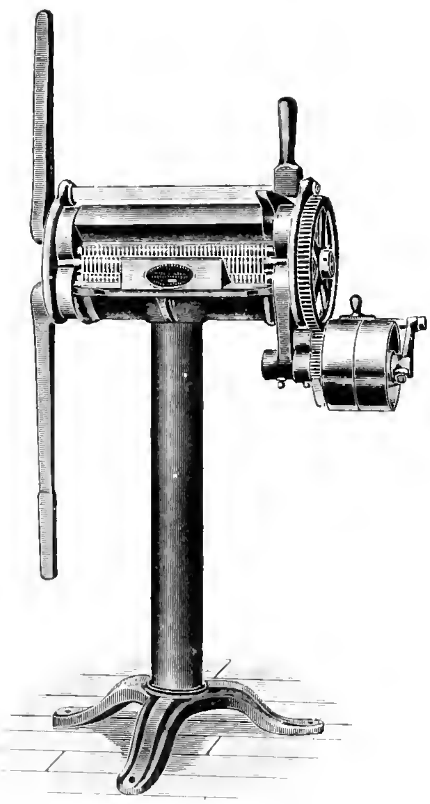
In considering the methods pursued by the Atchison, Topeka & Santa Fe Railway, whereby the expense of maintaining the belting in the shops at Topeka was reduced in less than two years from $1,000 to $275 per month and the belt failures from 300 to 55 per month (AMERICAN ENGINEER, December, 1906, page 455), mention was made of the Jackson machine lace. On the Santa Fe when a new belt is installed it is fitted with what is known as a "take-up" piece about 6 in. long. As the belt



JACKSON MACHINE LACE.

stretches this piece can readily be removed and replaced in a few minutes by a shorter one, it being only necessary to apply a clamp, withdraw the two raw-hide pins, slip out the "take-up" piece, draw the ends of the belt closer together and apply a new piece. Various lengths of these "take-up" pieces are kept in stock in the belt room, as shown in the illustration on page 456 of the December, 1906, issue.

The application of the machine lace to a piece of belting, as well as the machine for making the lace, are shown in the accompanying illustrations.



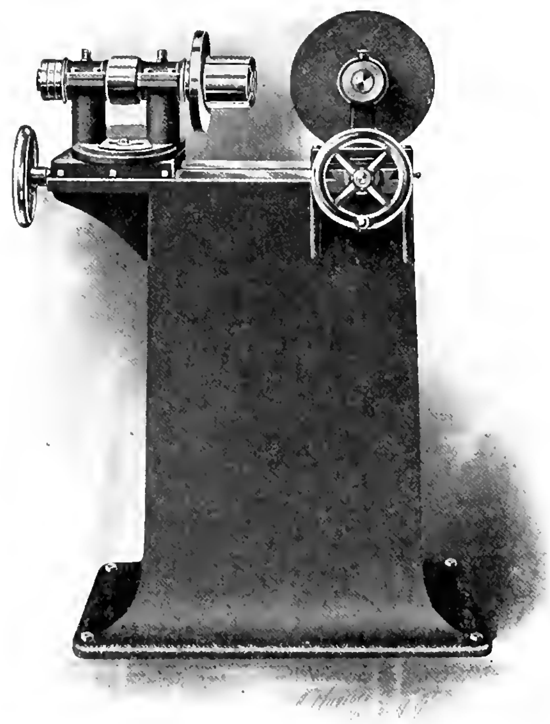
JACKSON BELT LACING MACHINE

The lacing, called the wire coil clasp lacing, is of wire and the connecting pin is of raw hide, making a strong and flexible joint. After the wire coil has been put through the end of the belt pressure is applied so that the lacing does not project beyond the face of the belt, and it, therefore, passes over the pulley noiselessly and without slipping. The cost of this lacing is said to be only about one-quarter that of the ordinary method, and it is claimed that it will last three times as long. A 6-in. belt can be laced complete in three minutes. A piece of 2½-in. belt laced in this manner stood a tensile strain of 1,000 lbs. without breaking or pulling apart.

The construction of the machine is very simple, as may be seen from the illustration; it requires only a small amount of floor space, and is comparatively inexpensive. The machines are made in four sizes to lace belt up to ½ in. in thickness and 6, 12, 18 and 24 in. in width. They are made by the Birdsboro Steel Foundry & Machine Company, Birdsboro, Pa.

SLITTER AND DISC GRINDER.

This machine, made by The Bridgeport Safety Emery Wheel Company, Bridgeport, Conn., is made with a universal chuck for grinding punches, dies, flat faces and circular pieces. The expanding arbor is opened and closed by a screw. Both heads swivel to any angle, thus enabling convex, concave or flat faces to be ground quickly. These heads are mounted on dove-tailed



BRIDGEPORT SLITTER AND DISC GRINDER.

ways, gibbed to take up wear and are fed in and out by a hand wheel and screw. The spindles on the heads are arranged with ring check nuts to take up all end play.

The machine may readily be adapted, with a few minor changes, for grinding a large variety of work. It can be equipped with a plain face plate, a Walker magnetic chuck or plain three or four jaw chucks. If desired it may be arranged for wet grinding, the wheel being enclosed with a hood and pans being placed to catch the water and conduct it back to a large tank in the base of the machine. The dirt and sediment settle to the bottom of the tank and the water is drawn from the top by a centritugal pump.

The leading dimensions are as follows:

Height from floor to center of spindle	40 in.
Length of bearings	4 in.
Diameter of spindle in bearings	1½ in.
Height from ways to center of spindle	6 in.
Diameter of face plate	7 in.
Size of wheel	10 x ½ in.
Distance between platen and wheel when new	6 in.
Weight	500 lbs.

ELECTRIC TRACTION IN ENGLAND.—Of course, electric traction will be made right in time, but at present the financial results of it are most distinctly discouraging, *e. g.*, it has reduced the Metropolitan dividend from 3 to 1 per cent., and on the District Ry. caused a deficit on working in six months of $187,000.—*Railway Engineer.*

PERSONALS

Mr. D. D. Briggs has been appointed master mechanic of the Louisville & Nashville R. R., at Montgomery, Ala.

Mr. E. A. Williams has resigned as general mechanical superintendent of the Erie R. R., and the office has been abolished.

Mr. J. E. Holtz has resigned as master mechanic of the Chicago, Rock Island & Gulf Ry., at Fort Worth, Tex.

Mr. P. J. Colligan has been appointed acting master mechanic of the Chicago, Rock Island & Gulf Ry., at Ft. Worth, Tex.

Mr. J. Schumacher has been appointed master mechanic of the Missouri Pacific Ry. at Ferriday, La., in place of Mr. R. W. Ruffner.

Mr. B. Donahue has been appointed master mechanic of the Missouri Pacific Ry. at Van Buren, Ark., to succeed Mr. F. K. Tutt.

Mr. F. K. Tutt has been appointed master mechanic of the Missouri Pacific Ry. at Osawatomie, Kan., succeeding Mr. W. B. Gaskins, resigned.

Mr. R. W. Burnett has been appointed asst. master car builder of the Can. Pac. Ry. lines east of Port Arthur, succeeding Mr. S. King, resigned.

Mr. I. W. Smith has been appointed master mechanic of the Great Northern Railway at Crookston, Minn., in place of Mr. R. H. Smith, transferred.

Mr. James N. Weaver, formerly for 20 years master mechanic of the Lehigh Valley R. R., at Sayre, Pa., died at his home in that city on February 13.

Mr. J. J. Flynn, general foreman of shops of the Louisville & Nashville R. R., at Mobile, Ala., has been appointed master mechanic at Nashville, Tenn.

Mr. F. P. Mooney has been appointed master mechanic of the Trinity & Brazos Valley Ry., with headquarters at Teague, Tex., succeeding Mr. W. C. Burel, resigned.

Mr. Warren Fogwell and Mr. D. F. Gonware have been appointed road foremen of engines of the Wabash R. R., at Decatur, Ill., succeeding Mr. J. S. Sweeney, resigned.

Mr. C. Gifford, master mechanic of the Louisville & Nashville R. R., at Montgomery, Ala., has been appointed master mechanic at Mobile, Ala., succeeding Mr. H. M. Minto, resigned.

Mr. R. W. Shultz, of Albany, N. Y., has been appointed general car foreman of the shops of the Atchison, Topeka & Santa Fe Ry., at Cleburne, Texas; vice Mr. D. W. Rasly, resigned.

Mr. R. B. Watson has been appointed engineer of tests of the Erie R. R. and the New York, Susquehanna & Western Ry., with office at Meadville, Pa., succeeding Mr. J. G. Platt, resigned.

Mr. John S. Lentz, master car builder of the Lehigh Valley R. R., with headquarters at Packerton, Pa., has been given jurisdiction of car repairs and shops over the entire Lehigh Valley system.

Mr. G. M. Ellsworth has been appointed chief motive power clerk of the Pennsylvania R. R., and Mr. O. A. Cherry has been appointed assistant chief motive power clerk, with headquarters at Altoona, Pa.

Mr. W. J. Haynen, shop superintendent of the Pere Marquette Ry., at Wyoming, Mich., and formerly master mechanic of the Detroit, Toledo & Ironton Ry., has been appointed superintendent of motive power of the Mississippi Central Ry., with office at Hattiesburg, Miss.

Mr. James Ogilvie, superintendent of motive power of the Ottawa Division of the Grand Trunk Ry., has been recommended by the Board of Railway Commissioners to the Canadian Government for appointment as inspector of rolling stock and general equipment of Canadian railways.

Mr. H. H. Hale, formerly assistant master mechanic of the Pere Marquette Ry., at Grand Rapids, Mich., has been appointed superintendent of motive power and consulting engineer of the Nevada R. R. and the Nevada Consolidated Mining & Milling Co., with headquarters at San Francisco.

Mr. Harrington Emerson has been appointed standardizing engineer of the American Locomotive Co., with office at 111 Broadway, New York. He will report to the vice-president in charge of manufacturing, and has authority to investigate and recommend standard methods of shop operation, shop accounting and handling material.

Mr. Harry C. Hoefinghoff, president and general manager of the Bickford Drill & Tool Company, Cincinnati, Ohio, died March 2. He was 35 years of age and had been president of the company since 1899, when he succeeded his father. The company has grown rapidly and been very successful under his administration, and his loss will be felt not only by it but by the machine tool builders' fraternity at large, of which he was a very prominent member.

ESTIMATING LOCOMOTIVE SPEED.—A simple way to arrive at the speed on the hard pulls when a train is moving slowly, is to count the number of exhausts for ten seconds. If this is done, and the diameter of the drivers outside of tires is known, the speed in M. P. H. can be accurately found by multiplying the diameter of the drivers in inches by the exhausts in ten seconds and dividing by 225.—*Mr. C. D. Buell, before the Traveling Engineers' Association.*

BOOKS

Statistics of Railways in the United States, 1905. Report of the Interstate Commerce Commission. Government Printing Office, Washington, D. C.

This is the yearly report of the Interstate Commerce Commission and contains about 700 pages of statistics of all kinds on the railways of the United States.

Watts Official Railway Guide. Published monthly by the Watts Publishing Company, Atlanta, Ga. Subscription price, $2.00 per year.

It contains railway time schedules, connections and distances; hotel directory, shipping and postal guide; gives all railway stations and principal towns, together with the population and other information for the Southern States. The publication is now entering upon its 22nd year and will be found of much value to travelers in that section of the country.

Up-to-Date Air Brake Catechism. By Robert H. Blackall. 21st edition, revised and enlarged. Published by the Norman W. Henley Publishing Company, 132 Nassau street, New York. Price, $2.00.

A new edition of this well known work which has again been brought "up to date" has just been finished. The addition of an appendix which fully describes the improved air brake devices which have appeared since the revision was finished brings the subjects strictly up to the date of going to press. The whole work has been completely revised in all parts and is undoubtedly the best book on the Westinghouse air brake obtainable to-day.

Questions and Answers from The Gas Engine. 275 pages. 5 by 7. Cloth. Published by the Gas Engine Publishing Company, Cincinnati, Ohio. Price, $1.50.

This book has been compiled from the "Answers and Inquiries" column in *The Gas Engine*, and contains answers to questions relating to the design, construction, operation and repair of gas and gasoline engines for stationary, marine and automobile use. These answers have been made by some of the best recognized authorities on the subjects in both America and Europe, and will be found to very completely cover the field. A complete index is included, permitting rapid reference to any desired subject.

Railroad Pocket Book. By Fred H. Colvin. Bound in flexible cloth. 4 by 6. Published by the Derry-Collard Company, 109 Liberty St., New York. Price, $1.00.

This book has been prepared to give in a convenient form, information which is constantly being required in all different branches of railroad

service. It gives a vast amount of such information in a brief and clear manner and in a handy form. The whole book is alphabetically arranged and is practically an encyclopedia of railroad matters boiled down into pocket book form. Matter is included for all different departments and illustration are given wherever needed. The mechanical department has been well taken care of in this work, which includes not only much matter obtainable in other places, such as M. C. B. and M. M. standards, but also a large amount of information which is not readily available to the ordinary man, as for instance, the cost of stopping trains, coal consumption, analysis of different coals, etc. This work is to be highly recommended and will no doubt prove, after a brief trial, to be practically invaluable to its possessor.

CATALOGS

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS JOURNAL.

Second-Hand Machine Tools.—The Niles-Bement-Pond Company is sending out list No. 13 containing descriptions of 204 second-hand metal-working machine tools of all kinds which they have for sale. Copies may be had by addressing the company at 111 Broadway, New York City.

Storage Batteries.—The Willard Storage Battery Co., Cleveland, Ohio, is issuing a catalog which illustrates and gives complete data on several different types of portable storage batteries which have been developed after many years of experience in this business. Complete data, together with prices of complete apparatus and parts, is given for each type.

Vertical Enclosed Fan Engines.—A revised edition of Bulletin No. 125 in the Sturtevant Engineering Series has just been issued by the B. F. Sturtevant Company, of Boston, Mass. It describes the line of vertical forced-lubrication enclosed engines which this company manufactures in eighteen different sizes, ranging from 5 x 5 to 12 x 10 in. A sectional view makes clear the method of positive lubrication.

Coal and Ash Handling.—The Jeffrey Manufacturing Co., Columbus, Ohio, is issuing a pamphlet devoted largely to illustrations of several recent installations of coal and ash handling apparatus. Most of them employ grab buckets handled by a jib or traveling crane. Cross sections of typical power houses are an interesting part of the pamphlet. Another pamphlet being issued by the same company shows the application of the traveling bucket conveyor for the same purposes.

The Business Boomer.—S. F. Bowser & Co. are making a practice of issuing twice a month a pamphlet entitled "The Bowser Business Boomer." A recent issue contains a primer, which, while written particularly for the Bowser salesmen, is applicable to almost any line of business. The Boomer is issued in the interests of the selling force of the company, which now numbers nearly 2,000 men, and contains much of a humorous, personal nature, as well as good advice for obtaining new business.

Locomotive Sanders.—The American Locomotive Sander Company, Philadelphia and Chicago, is issuing a very attractive catalog illustrating and describing the several different designs of Leach and "She" air sanders. These are shown in single, double and triple designs, the apparatus in each case being clearly shown by phantom and sectional views, as well as illustrations of detail parts giving the proper name for ordering. An arrangement for automatic sanding in connection with the engineer's air brake valve is also shown.

Gasoline Storage Tanks and Pumps for Automobiles.—S. F. Bowser & Co., Ft. Wayne, Ind., is prepared to furnish several different designs and arrangements of underground tanks and connecting pumps for the storage of gasoline in the garage, and are issuing a catalog which illustrates and describes them. Designs are shown with both self-measuring and other types of pumps for either long or short distance service. In all cases the tank is buried in the ground and when once put into the tank, the gasoline is not exposed to the air at any time until it reaches the carbureter. Several different designs of tanks and pumps for storage of lubricating oils for automobiles are also shown.

In the Maine Woods.—The Bangor & Aroostook Railroad, Mr. George H. Houghton, passenger traffic manager, Bangor, Me., is issuing a magazine with the above title. This contains over 130 pages of reading matter profusely illustrated with photographic views of hunting and fishing scenes in the Maine woods, a number of which are colored. The articles are based on life in the woods, being both interesting and instructive. Following the reading matter there are over 70 pages of advertising, which includes a large number of camps and hotels in different parts of Maine, in most cases showing views of the quarters. This book will be found to be most interesting to anyone interested in woods life.

Electrical Apparatus.—The General Electric Company is issuing a number of new bulletins which include numbers on the following subjects: No. 4485 gives a brief description and line drawings of portable gasoline engine and generator outfits. No. 4490 briefly describes portable air compressor sets, which contain motor, compressor and storage tanks mounted on a three-wheel truck. No. 4489 is on crane wiring supplies. No. 4492 is on small plant alternating current switchboards. No. 4487 is on small plant continuous current switchboard panels. No. 4488, which supersedes No. 4415, is on the Thompson recording wattmeter. No. 4491, which supersedes No. 4369, is a very completely illustrated catalog of controllers for power and mining service.

Light Locomotives.—A pamphlet recently issued by the American Locomotive Company illustrates and describes light locomotives, both steam and compressed air, adapted for the use of contractors, mines, logging roads, plantations and industrial plants and for a wide range of service on light rails and poor roadbed. The pamphlet contains 31 illustrations of different designs and types, and on the page opposite each illustration is a table giving the principal dimensions of designs, of progressive weights and hauling capacities of the type illustrated. The last part of the pamphlet is devoted to engineering data and contains a number of very useful tables and formulæ.

Crucibles.—The Joseph Dixon Crucible Co., Jersey City, N. J., has published a very attractive pamphlet on graphite crucibles, their care and use. The author of this work is Mr. John A. Walker, vice-president and general manager of the company, who is fitted by his forty years' service in this field to speak as an authority on the subject. The purpose of the book is to instruct users of crucibles as to their proper care and the dangers of abuse. Most crucibles are perfect when they reach the user and their failure, in practically all cases, is due to ignorance of the proper method of handling. Rules are given for annealing and a word as to its importance; how to put the metal in the crucible; how to put the crucible in the fire; what sort of fuel to use, etc. The pamphlet also contains tables showing the make-up of the principal alloys; the freezing, fusing and boiling points of certain materials and other general information useful in foundry work. A double page colored picture in the center of the book shows a most realistic and vivid foundry scene. The book is profusely illustrated and will be found to be of much value to the users of crucibles.

NOTES

Quincy-Manchester-Sargent Company.—This company announces that after April 1 the machinery sales department will be removed from Plainfield, N. J., to the new West Street Building, No. 90 West street, New York City.

American Steam Gauge & Valve Mfg. Company.—The Chicago office of the above company, which for the past 20 years has been located at No. 10 N. Canal street, has been removed to No. 7 South Jefferson street, where much larger quarters have been leased. This will allow this office to carry a much larger stock than has heretofore been possible.

American Blower Company.—This company has just finished a large addition to its steel plate fan shop and is planning on a large addition to the power plant and also to the engine construction department. It is stated that business is growing so rapidly that it is with difficulty that the continual increase in size of the plant can be made to keep up with the output demanded.

Safety Car Heating & Lighting Company.—This company announces the removal of its general offices from 160 Broadway to the new United States Express Building on the corner of Trinity Place and Rector street, New York. It has leased the entire seventeenth floor of that building. Announcement is also made of the appointment of Mr. W. L. Garland as general agent of the company at Philadelphia, Pa.

Independent Pneumatic Tool Company.—This company reports that it has received a large order for Thor piston air drills, and pneumatic hammers from the Wisconsin Engine Company, which was placed only after an exhaustive test of practically every make of pneumatic tool on the market, lasting about three months. It is stated that the Thor tools showed greater efficiency and durability than any others in the competition.

Pintsch Gas Lamps in Germany.—The Directors of the Prussian State Railways have decided to change the lighting equipment of all cars on its lines to the incandescent gas lighting system, which change will be effective before the end of 1909, after which date they will manufacture only Pintsch gas and not Pintsch gas enriched with acetylene as is at present used. All new cars built during 1907, to the number of about 3,800, will be equipped with the new mantle lamps.

Recent Electrical Equipment in Railroad Shops.—The Western Maryland Railroad in its new division shops at Hagerstown, Md., has installed one 150 kw. and one 250 kw. Allis-Chalmers direct current generator, together with a small motor generator set, for furnishing power to drive the shop tools and light the shops and terminal. The Norfolk & Western Railway are also installing Allis-Chalmers alternators, one of 175 kw. and one of 150 kw., for carrying the motor and lighting load of its shops at Bluefields, W. Va.

Pittsburg Steel Company.—This company, which is the largest independent steel manufacturing concern in the country, will build a $7,000,000 addition to its plant at Monessen, Pa., which will include two new blast furnaces, a blooming mill and an open hearth furnace. The company has also recently secured some valuable ore lands, and it is stated that at the expiration of its contract with the United States Steel Corporation, two years hence, it will be able to make its own steel billets, these now being secured from the steel corporation. The new blast furnaces, etc., will make the Monessen plant one of the best in the country and will enable it to enter into competition for contracts of large size for cold drawn steel, the manufacture of which is at present confined almost entirely to the steel corporation. The new plant will have excellent transportation facilities by both water and rail.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

MAY, 1907

MAINTENANCE AND REPAIR OF STEEL FREIGHT CARS.

BALTIMORE & OHIO RAILROAD.

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The Growing Demand for Steel Freight Cars.

Railroads in the coal and ore districts have been using steel hopper and gondola cars for a number of years with very satisfactory results. Generally speaking, the roads which do not have a specially heavy traffic of this kind have continued to use either all-wood gondolas and hoppers, or cars with steel underframes and wooden bodies. The gradual but steady increase in the price of lumber and the difficulty in getting a sufficient quantity of a satisfactory quality have caused a number of roads, that formerly used wooden equipment exclusively, to consider seriously the introduction of steel cars and, in some instances, to order a small number of these cars as an experiment.

It is interesting to note that although the prices of steel and lumber have fluctuated considerably during the past ten years, the movement of the price of lumber has practically always been upward, while an increase in the price of steel has usually been followed after an interval by a reduction, and therefore, if the merits of the all-steel and the wooden car are considered from a standpoint of first cost only, it will probably be only a comparatively short time before the steel car can be purchased as cheaply as the wooden car. The steel car, from the standpoint of maintenance and repairs, has, however, many advantages over the wooden car, as may be seen from a careful study of this article. It also, of course, has advantages as concerns service and operating requirements, but no attempt will be made to consider these at this time.

In considering the introduction of steel cars the motive power officer is confronted with two problems. The first one is: What facilities will have to be provided for repairing and maintaining these cars? The second: What is the probable life of a steel car? The purpose of this article will be to answer these two questions, as far as possible, from the experience of the Baltimore & Ohio Railroad. The problem of maintaining and repairing steel cars is a simple one and can best be demonstrated by a visit and a few days' study of the question at a large steel car repair point. It is hoped, however, that by describing the facilities required for this work and a number of typical repairs which are being made the reader may obtain a clear conception of how it is handled.

The Life of the Steel Car.

It is practically impossible to damage a steel car so badly that it cannot be repaired to advantage. This may readily be seen by the data in the following section, showing that of over 23,000 all-steel cars on the Baltimore & Ohio, a large number of which have been in service for as long as eight years, only eleven have been destroyed. Three of these were destroyed on the Baltimore & Ohio, shortly after steel cars were first introduced, on account of the salvage being picked up and scrapped, instead of being diverted to the repair station for reassembling. The others were destroyed on foreign lines, and it is safe to say that probably all of them could have been repaired to advantage with the present knowledge of and facilities for repairing steel cars.

A great deal has been said in a general way concerning the corrosion of steel cars and various authorities have estimated that the sheets in these cars would last from seven to twenty years or more. As a matter of fact very little exact data has been presented. The first modern steel cars which were introduced on the Baltimore & Ohio in 1899 were equipped with floor and side sheets about 3/16 of an inch thick. These cars have been in continuous service since that time, the hopper cars being used very largely for carrying bituminous coal, and yet instances are very rare of the sheets being seriously damaged by corrosion, except where flat bottom cars are held under load for long periods with high sulphur bituminous coal and subjected to rains and the resulting effect from the mild sulphuric acid which is formed. The greater number of these cars have not been entirely re-painted during the eight years and the physical conditions on the Baltimore & Ohio are less favorable for equipment of this kind than on many other railroads. On certain portions of the road there are a great many tunnels and in passing over the mountains there are, of course, many curves. While a number of the earlier cars have been on the repair track, during the past year or two, for heavy repairs, due to weakness in design, there is no record of any of these sheets having to be replaced due to wear or tear, although in a number of instances the cars have been so badly damaged as to require the floor and side sheets to be heated in a furnace to be straightened. If they had been worn to any great extent it would have been very apparent at such times. In a very few instances holes have been found in the sheets, due to corrosion, but such cases

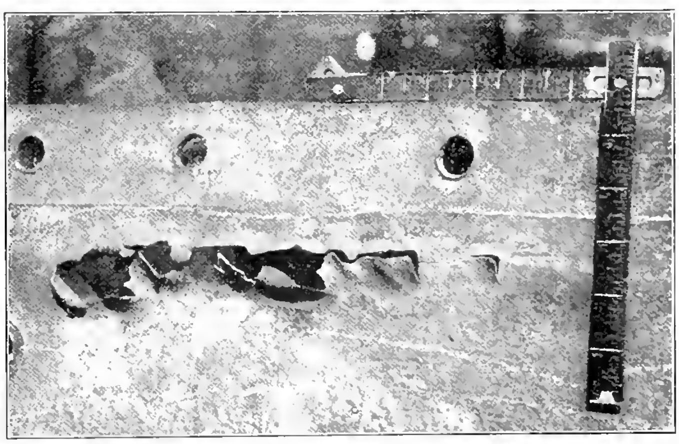

FIG. 1.—CORRODED END SHEET ON A GONDOLA CAR.

are very rare and were apparently not always entirely due to that cause.

During the writer's visit to the Mt. Clare repair yards a gondola car, which had been placed in service in 1899, was brought in for repair of damage due to rough handling. The sheets were found to be very badly corroded, in fact they were stated to be by far the worst that had ever been noticed in the repair yard. The end sheet was eaten through just above the floor sheet, as shown in the photograph, Fig. 1. The only indication was a slight crack and this was opened up by a hammer. The lower edge of the side sheet on these cars is riveted between a flange on the floor sheet and a flange on the end sill and is thus pro-

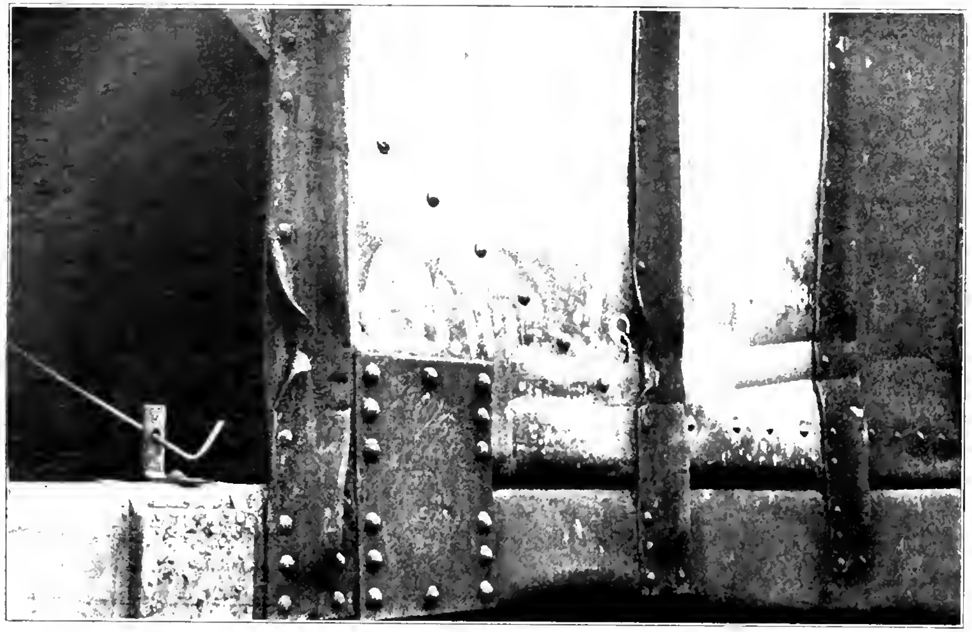

FIG. 2.—SIDE STAKES INJURED BY CORNERING.

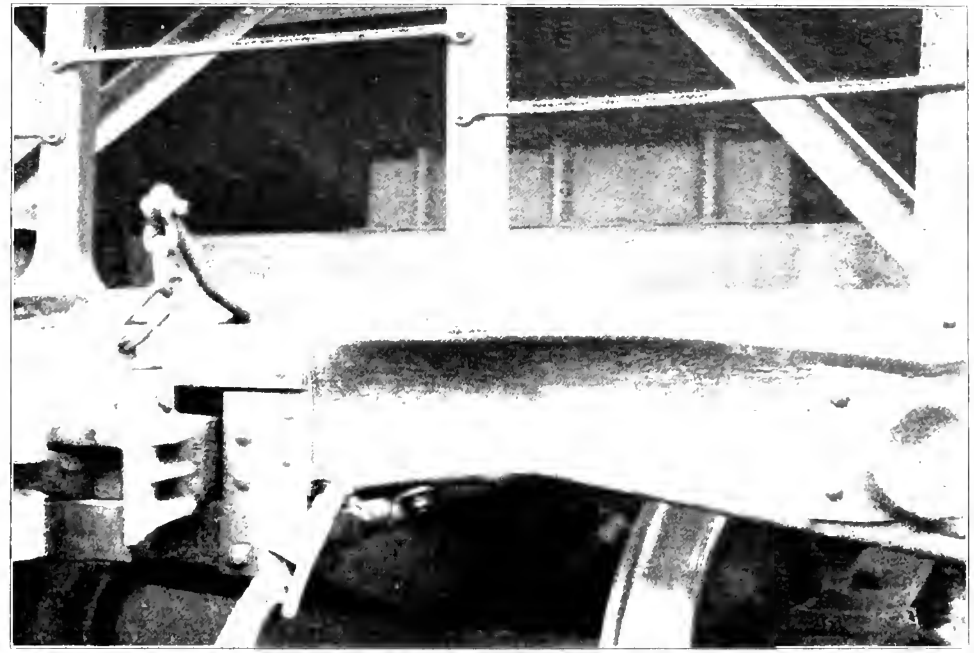

FIG. 3.—BADLY BENT END SILL ON HOPPER CAR.

FIG. 4.—SIDE SILL EXTENSION ON HOPPER CAR DAMAGED.

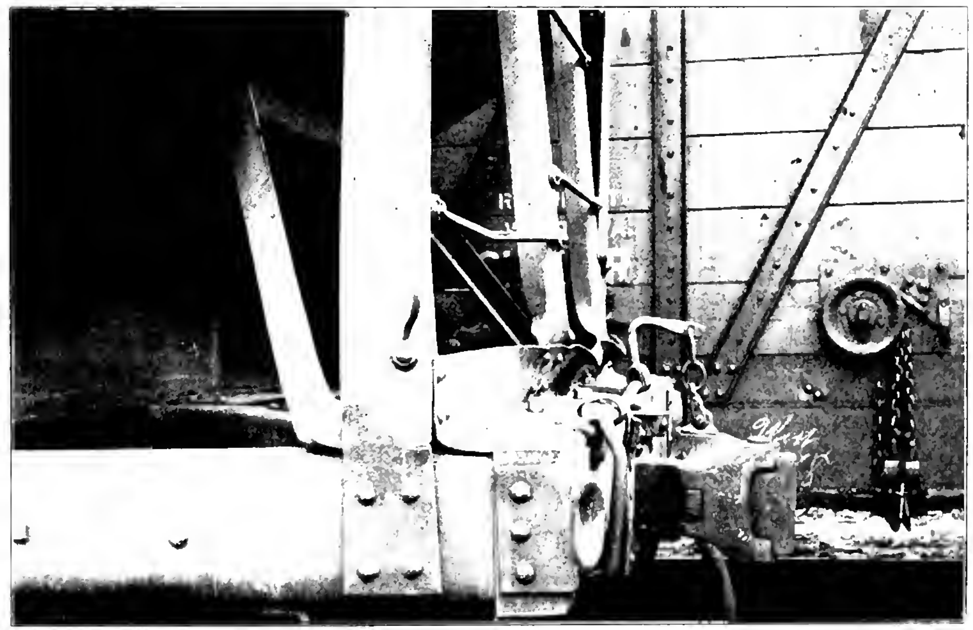

FIG. 5.—UPRIGHTS AND UPPER PART OF END SILL PLATE DAMAGED.

ILLUSTRATIONS OF DAMAGE WHICH WOULD NOT INTERFERE WITH THE OPERATION OF A STEEL CAR, BUT WOULD PUT A WOODEN CAR OUT OF SERVICE.

tected from wear and corrosion, and was therefore in practically the same condition as when it was first erected. An examination of this edge indicated that the sheet was apparently of uneven thickness when it came from the rolls and much less than normal thickness when it was put in place. A heavy coat of rust was found on the floor, side and end sheets, but they were not damaged sufficiently to make it necessary to replace them, and a couple of simple patches on the end sheet was all that was required to put the car in good service condition. The same end sheet was eaten through at the other corner of the car, although the damage was not as bad as on the end shown in the illustration.

As has already been noted, the greatest deterioration found in steel cars occurs when they are out of service and under load with high sulphur bituminous coal. If cars are kept continually in service and under load, the friction between the lading, and the plates on the inside, due to loading and unloading, tends to act as a preserving instead of a deteriorating influence. Cars held under load, out of service, will deteriorate very rapidly, especially during the winter weather, on account of the continuous action of the mild sulphuric acid on the plates. This, of course, applies more to the flat bottom than to the inclined bottom cars. On new equipment ¼ in. side sheets and 5/16 in. floor plates are being applied with a view of overcoming the difficulty, due to corrosion, that is now being experienced in connection with the first all-steel cars. The lower parts of the side sheets of flat bottom all-steel cars, as well as of the hopper cars, and the floor plates of the flat bottom all-steel cars will be the first to give away, and as this occurs the corroded portions will be cut out and patches and angle plates will be applied.

The Baltimore & Ohio has about 7,000 all-steel cars which have been in service since 1899, and although the side and floor sheets on these cars were less than ¼ in. in thickness, probably not more than 3/16, when they were installed, their condition at the present time is such that they will probably give good service for a number of years to come and it is conservatively estimated that the floor sheets will be in fairly good condition after they have been in service for at least twelve years and that the side and end sheets will last for a longer time. The underframes are apparently in practically as good condition as when they were first put in place, and under normal conditions should have a life of at least twenty years. It is estimated that the 5/16 in. floor sheets and the ¼ in. side sheets used on the more recent cars will have a useful life of at least twenty years and the life of the underframe, which is much stronger than that used on the earlier cars, should be twice as long. Where the sides of the car form part of a side girder it is essential that they be sufficiently thick when they are new to allow for corrosive action, depending upon the life that may be desired of the car.

The corrosion is much worse on the inside of the car than on the outside, that on the outside being hardly perceptible, although the cars in some instances had not been re-painted since they were placed in service eight years ago.

The fact that the inside of the car may be covered with a very thick coating of rust does not necessarily indicate that very much metal has been eaten away, as may be seen by the result of some tests recently made by Mr. J. R. Onderdonk, engineer of tests. A piece of rust 5/32 in. thick was analyzed and found to consist of 90 per cent. Fe_2O_3 and 10 per cent. H_2O. In addition slight traces of silicon, calcium and other organic substances were found. The actual thickness of the metal which had been rusted would be .031 in., or about 1/5 of the thickness of the piece of rust.

Apparently the parts which will fail first on the more recent designs of cars having hoppers are the side sheets directly above the hopper doors. When the lading has become frosted, or damp and closely packed, it is the practice to strike the side sheets near the hopper opening in order to loosen it. In some instances the man stands on top of the car, using a hand bar to loosen the lading, and the sloping sheets of the hopper are often struck with these bars, injuring them. These thin spots will probably be eaten through first, but they can easily be patched at a small expense, if necessary.

The Repair Question.

The steel cars are much stronger than the wooden ones and are not so easily damaged. As stated by Mr. J. F. MacEnulty, of the Pressed Steel Car Company, in a paper recently presented before the New England Railway Club, the figures giving the comparative cost of maintenance of steel and wooden cars, as they are ordinarily presented, do not take into consideration the fact that steel cars are seldom damaged to such an extent that they cannot be repaired to advantage, while wooden cars are very often destroyed. The records show that only three Baltimore & Ohio modern steel cars have been destroyed on that system and this would not have occurred under present methods of handling salvage. Eight of their steel cars have been destroyed on foreign lines, but they could undoubtedly have been repaired if the roads upon which the damage occurred had been accustomed to repairing cars of this kind. Of these eight cars one, a hopper, was built in 1902 and was destroyed the same year; a gondola car, which was built in 1901, was destroyed in 1904; three flat cars, which were built in 1902, were destroyed in 1904; a hopper car, which was built in 1899, was destroyed in 1906; and two gondola cars built in 1901 were destroyed, one in 1905 and the other in 1906.

Skilled mechanics are not required to repair these cars successfully. It is the practice on the Baltimore & Ohio to take the men for the steel car repair gangs from among the wooden car repairmen. As will be seen from the section dealing with the facilities provided for repairs, practically no special equipment is required; the cost of the equipment for carrying on this class of work is less than that for the repairing of wooden cars. This applies not only to the tools used by the repairmen, but to the ground space and facilities required for pressing and straightening sheets, etc., as compared with a plant for preparing the timber used on wooden cars.

As far as the repair yard is concerned, it need not be any more extensive or elaborate than would be required to take care of the same number of wooden cars. In the section describing some of the methods used in making typical repairs on the Baltimore & Ohio cars the greater number of defects illustrated are for damage to the earlier cars introduced on the system, which were among the first modern steel cars to be used in large numbers in this country. These designs in the light of present day experience were faulty in a number of respects, due both to the fact that service conditions since 1899 have become very much more severe than could be foreseen at that time, and also to the fact that the development of the design of the modern steel car was very rapid. It is, therefore, not to be wondered at that defects have developed in some of the earlier designs, in fact it is rather surprising that these cars have stood up so well under the severe conditions that they have had to withstand. As may be seen, such defects as have developed may be very readily overcome at a comparatively small expense when the cars come in for repairs.

Liability of Damage to Steel and Wooden Cars.

The steel cars being stronger are not as easily damaged as the wooden ones. Shocks which would seriously damage a wooden car often do not injure the steel car at all, or, if they do, do not render it unfit for service. For instance, in passing through a large freight yard steel cars may be seen that have been damaged by blows which would crush the corresponding part on a wooden car, but which on the steel car are not serious enough to take it out of service for repairs. The accompanying photographs, Figs. 2, 3, 4 and 5, illustrate conditions of this kind.

The first one, Fig. 3, shows an end sill which has been badly bent, but the center of the sill at the coupler is not affected. No attention is paid to defects of this kind, but it may readily be seen that if the end sill of a wooden car had received the same blow it would have been splintered and not only the end sill, but adjacent parts would have been damaged. Fig. 2 shows the results of "cornering," which has torn the side braces, damaging them to some extent, although not enough to warrant re-

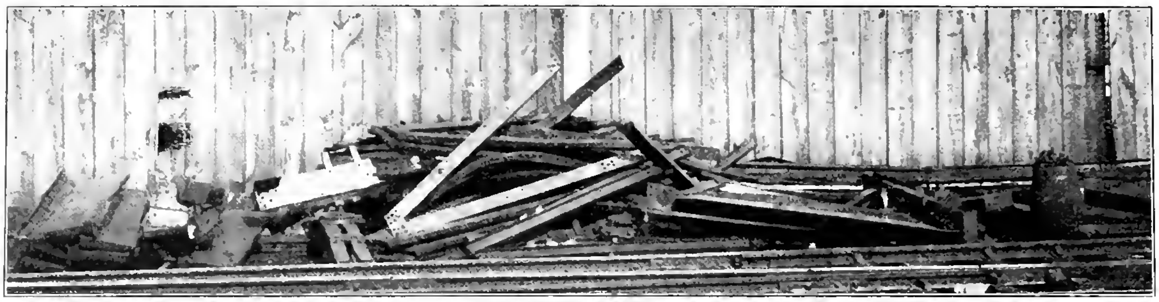

FIG. 6.—USEFUL MATERIAL FROM SALVAGE OF FIVE COMPOSITE CARS.

pairing or replacing them. The same blow on the side of a wooden car with outside stakes would undoubtedly have injured some of them so that they would have had to be renewed. Fig. 4 shows the side sill extension on one of the recent types of hopper cars which has been bent in, but not enough to affect the step, hand hold, or push pole casting. Fig. 5 shows the upper part of the end sill plate damaged, also two of the uprights supporting the end of the hopper. Beyond the straightening of the hand hold at the corner no repairs will be required, as the strength of the car has not been materially affected.

In accidents the composite car with steel framing for the body is very little better than the wooden car. As an illustration, the pile of material shown in Fig. 6 is all the useful material that remains of the bodies of five composite cars after the salvage had been sorted out. The sills of these cars are not shown in the illustration, but they consisted of structural steel members and were badly bent, some of them with the flanges of the channels broken. In this connection it is important to note that experience on the Baltimore & Ohio has demonstrated that pressed steel shapes are preferable to rolled shapes. A rolled shape, if the flange is broken, cannot very well be repaired satisfactorily, although this can be done readily with a pressed steel shape. An inferior quality of material can be used in rolled shapes, but first-class material only can be used for sheets which are to be pressed, and if the proper material is not used it is impossible to bend the sheets successfully. The material is such that it can easily be rebent and repaired if it is damaged or bent out of shape. The old argument was that it was better to use structural shapes because they can be obtained readily upon the open market, while the pressed shapes can be obtained only from one source, *i. e.*, the car manufacturer.

FIG. 7.—BODY OF ONE OF A SERIES OF IRON BOX CARS INTRODUCED ON THE BALTIMORE AND OHIO RAILROAD IN 1862.

Experience to the present time has demonstrated that it is only very seldom that new parts of this kind are required, it being possible to repair practically any defect which may occur. This is clearly shown in the latter part of this article.

A possible justification for building composite cars is where there is a heavy demand for cars which must carry top loads, the wooden sides making it possible to use cleats, and the load can be braced with much less trouble and expense than on a steel car. If the lading in the steel hopper or gondola car, carrying coal or ore, becomes frozen the usual practice is to build a fire under the steel car and thaw it or to dynamite it out. These measures, of course, cannot be used in the case of wooden or composite cars.

Baltimore & Ohio Steel Freight Car Equipment.

The Baltimore & Ohio Railroad was one of the first to introduce extensively the modern type of steel car. For a great many years previous to the advent of the steel car, it had in service and maintained a large number of cars with iron bodies and wooden underframes. One of the first cars of this kind was an iron box car built in 1862. Previous to that time a number of cars were in service for carrying gunpowder, which were similar to an ordinary tank car, but having doors in the ends. These cars were not suitable for general merchandise purposes, and in 1862 and the three or four following years, two or three hundred of these iron box cars were built at the Mt. Clare shops. Their construction and the service they gave are of interest, especially since the first modern all-steel box car has just been built and put in service on the Union Pacific Railroad. (See page 129 of the April issue.)

During the summer months these cars absorbed the heat so that they did not prove very successful for general merchandise purposes. They were afterwards used for hauling lime, but were not an entire success for that purpose as the lime was carried in bulk, and during certain seasons the cars "sweat" and caused trouble by slacking the lime. The accompanying illustrations, Figs. 7 and 8, illustrate the general construction of these cars. The photographs were taken at Locust Point, near Baltimore, where the body of the car is now serving time as a car inspectors' quarters. The two windows at the side have been added since the car was taken out of service and this is also true of some of the patches at the lower edge of the side sheets. The interior view of the car gives a fairly good idea of the side, end and roof construction. The side posts and carlins were of 2 x 2 in. oak. The iron sheets were 1/8 in. in thickness, or about the same as the steel used on the new Union Pacific box car. The bodies of these cars were about 24 ft. long, 8 ft. 2 in. wide at the widest part, and 7 ft. 1 in. high from the lower edge of the underframe to the top of the car. They weighed about 18,000 lbs. The door opening was 4 ft. 10½ in. x 5 ft. The underframe was of wood and the trucks were of the double arch bar type and were equipped with 31 in. wheels.

In the late seventies or the early eighties a hopper having an iron body and known as the "three pot" hopper was introduced on the Baltimore & Ohio in large numbers. These cars were patented by Ross Winans, and for a long time the Baltimore & Ohio maintained what is known as "the hopper shop" for building them. The earlier cars were of 13 tons capacity, weighing 12,800 lbs., but in 1883 cars of this type of 20 tons capacity

STEEL GONDOLA CARS.

Date built	1899	1901	1906	1906
Class	O-12	O-14	O-17	O-17
Type	Flat bottom with drop doors	Twin Hopper	Twin Hopper	Twin Hopper
No. built	3,000	4,000	1,000	2,000
Road numbers	37,000 to 39,999	40,000 to 43,999	136,000 to 136,999	137,000 to 138,999
Capacity, marked, lbs.	80,000	80,000	100,000	100,000
Capacity, maximum, lbs.	91,000	91,000	125,000	125,000
Weight, lbs.	31,700	33,900	46,300	46,300
Length, inside	34'	34'	40' 6"	40' 6"
Width, inside	9' 2"	9' 2"	9' 3"	9' 3"
Height, inside	3' 10"	3' 10"	4' 2"	4' 2"
Width over sides, extreme	9' 9½"	9' 9½"	9' 10¼"	9' 10¼"
Height, top of rail to top of side	7' 4¼"	7' 4¼"	8' 9/16"	8' 9/16"
Door openings	2' 8½" 3' 1 7/16"	2' 8½" 3' 1 7/16"	2' 10" 2' 10⅞"	2' 10" 2' 10⅞"
Builder	Pressed Steel Car Co.	Pressed Steel Car Co.	Pressed Steel Car Co.	Cambria Steel Co.

In addition to the above equipment there are five hundred and fifty 80,000 lb. capacity cars which were built in 1899 for the Baltimore & Ohio South Western.

STEEL HOPPER CARS.

Date built	1899	1899	1900	1902	1906	1906
Class	N-8	N-9	N-9	N-9	N-10	N-10a
No. built	1,000	2,000	2,000	4,000	1,000	2,000
Road numbers	26,000 to 26,999	20,000 to 21,999	22,000 to 23,999	120,000 to 123,999	124,000 to 124,999	125,000 to 126,999
Capacity, marked, lbs.	95,000	100,000	100,000	100,000	100,000	100,000
Capacity, maximum, lbs.	110,000	117,000	117,000	117,000	125,000	125,000
Weight, lbs.	34,800	36,700	36,700	36,700	43,600	43,100
Length, inside	30' ¼"	30' ¼"	30' ¼"	30' ¼"	31' 6"	31' 6"
Width, inside	8' 8½"	8' 8½"	8' 8½"	8' 8½"	9' 4"	9' 4"
Height, top of rail to top of side	10' 2¾"	10' 7¾"	10' 7¾"	10' 7¾"	10' 7¾"	10' 7¾"
Builder	Schoen-Pressed Steel Car Co.	Pressed Steel Car Co.	Pressed Steel Car Co.	Pressed Steel Car Co.	Pressed Steel Car Co.	Amer. Car & Fdy. Co.
Width over outside, extreme	9' 4¼"	9' 4¼"	9' 4¼"	9' 4¼"	9' 11½"	9' 11½"
Door openings	2' 1" 2' 11¼"	2' 1" 2' 11¼"	2' 1" 2' 11¼"	2' 1" 2' 11¼"	2' 6" 2' 7¾"	2' 6" 2' 7¾"

In addition the present equipment includes 450 cars which were built by the Schoen Pressed Steel Car Co. for the Pittsburg & Western in 1898. These cars are 100,000 lbs. capacity.

were built, weighing 17,050 lbs. The diagram shown in Fig. 9 illustrates the general arrangement and size of the 20 ton capacity cars and explains why they were known as "three pot" hoppers. It is not now known just how many of these cars were built, but the road numbers which they were supposed to cover were from 20,001 to 22,499 for the 13 ton cars and 23,001 to 24,099 for the 20 ton cars. It is understood that some of them are still in service in the Cumberland district, but most of them have been scrapped for many years because of their being unsuitable for modern service.

The first modern steel cars were introduced on the road in February, 1899. The data for the various cars ordered since that time is shown above.

The road also has seven hundred 100,000 lb. marked capacity flat cars which were built in 1902 by the American Car & Foundry Co. These cars weigh 40,600 lbs., are 40 ft. 2 in. long and have wooden floors.

At the present time 23,636, or 28 per cent. of the 84,173 cars owned by the Baltimore & Ohio are of all-steel construction. In addition there are a large number of cars with steel underframes.

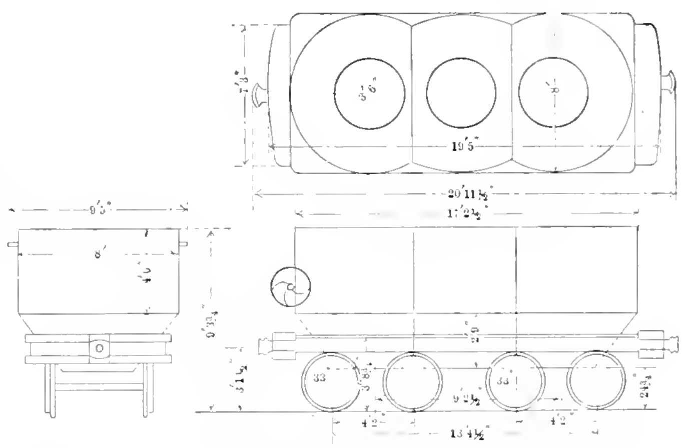

FIG. 9.—20-TON IRON BODY "THREE POT" HOPPER CAR INTRODUCED ON THE BALTIMORE & OHIO IN 1883.

FIG. 8.—INTERIOR OF IRON BOX CAR.

Organization of the Steel Car Repair Department.

As far as supervision is concerned there is no distinction between the steel car and wooden car repair work at Mt. Clare, which is the largest steel car repair point on the system. This work is carried on under the general direction of Mr. John J. Tatum, general foreman of the car department at the Baltimore terminals, who reports to Mr. J. E. Muhlfeld, general superintendent of motive power. The freight car repair work is in direct charge of Mr. J. W. Deible, foreman, and his assistant, Mr. M. V. Pascal. All the repair work is on a piece work basis.

Eight gangs of four men each are required for work on the steel cars. One of these gangs operates the flange fire shop where damaged material is straightened and reshaped. The other seven gangs are engaged in the repair yard. One man in each gang is known as the leader and directs the work of the gang. Each gang usually works on two cars at the same time. When one car is stripped and while the material is being straightened they work on the other car. In some instances after part of the work

has been erected two of the men will drive the rivets on one car while the other two work at stripping another. If there are an unusually large number of steel cars requiring repairs men from the wooden car force are shifted to this work and assist in stripping. On the other hand, if the steel car work is light and the wooden car work heavier than usual men from the steel car gangs are transferred to work on the wooden cars. The men for the steel car gangs are usually selected from the wooden car repair force. That this work does not require what is usually known as skilled mechanics may be gathered from the fact that one of the typical steel car repair gangs is made up of men whose former occupations were as follows: Trolley car conductor, huckster, iron worker and a car repairer from the truck department.

FIG. 10.—VIEW OF THE REPAIR YARD LOOKING EAST, FROM NEAR THE CENTER.

Facilities Provided for Steel Car Repairs.

Yard.—The locomotive shops at Mt. Clare have been extended from time to time so that at present the yard room for the freight car repair department is extremely limited and very much cramped, nevertheless the department is so organized that the work is very satisfactorily handled. That those who are up against the proposition of taking care of steel cars may realize more fully that this work does not require exceptional facilities and may even be done under conditions which would be considered adverse on some roads, the following facts are presented. There are five repair tracks with a material track extending along each side of the yard. These five tracks will accommodate from 17 to 21 cars each, with a space of 15 ft. between the cars requiring heavy repairs. The yard has a total capacity of 100 cars for medium and heavy repairs. The distances between the centers of the repair tracks are as follows: 11 ft. 4 in.; 14 ft. 4 in.; 14 ft. 6 in.; and 15 ft. 6 in.

When the steel car repair work was first started an attempt was made to keep it by itself, but the cramped condition of the yard and the large amount of work which it was necessary to turn out, together with the fact that both classes of work are under the direction of one foreman, made it advisable to put the cars wherever they could be placed to the best advantage, regardless of which type they belonged to. The two photographs, Figs. 10 and 11, taken from a box car in the middle of the yard, one looking east and the other looking west, give an idea of the general arrangement of the yard and the manner in which the steel and wooden car equipment is mixed. That one of the tracks in the view looking west is clear is due to the fact that a number of repaired cars had just been pulled out and the bad orders had not yet been switched in.

Tools.—The tools required are very simple; each gang has a small portable forge for heating rivets; a pneumatic riveter; a pneumatic drill; sledges; chisel bars; 5/8 in. and 7/8 in. drift pins; a pin maul; wrenches and a cold chisel or side cutter for cutting off rivets. The rivets are all cut off with a chisel or side cutter and sledge. A pneumatic hammer was tried for this purpose, but the men who are working on a piece work basis prefer the other method, probably because the steel is light and springs so that the heavy blow of the sledge is more effective than that of the hammer. For lifting the cars, 30-ton, geared jacks are used. These are designed for heavy car and locomotive use, weigh 237 lbs., have a height when down of 27 in., a total rise of bar of 17 in. and a rise of bar of 1/4 in. per stroke of the lever.

The department also has ratchet pulling jacks, and what is known as a "box" jack, which is shown in Fig. 12. This last is a relic of the old hopper shop. The screw of the jack is about 3 ft. long, and the housing or standard in which it works is encased in a hard oak box and is backed by an oak plank, as shown. The jack is used for forcing the side sheets outward in erecting and also for straightening bent sheets in place.

Flange Fire Shop.—The flange fire shop, which is shown in Fig. 13, is placed alongside one of the material tracks, and that part of it which is used for steel car work is about 20 ft. wide and 50 ft. long. The frame of the building is partly of wood, although largely of structural steel, and is covered with sheet

FIG. 11.—VIEW OF THE REPAIR YARD LOOKING WEST, FROM NEAR THE CENTER.

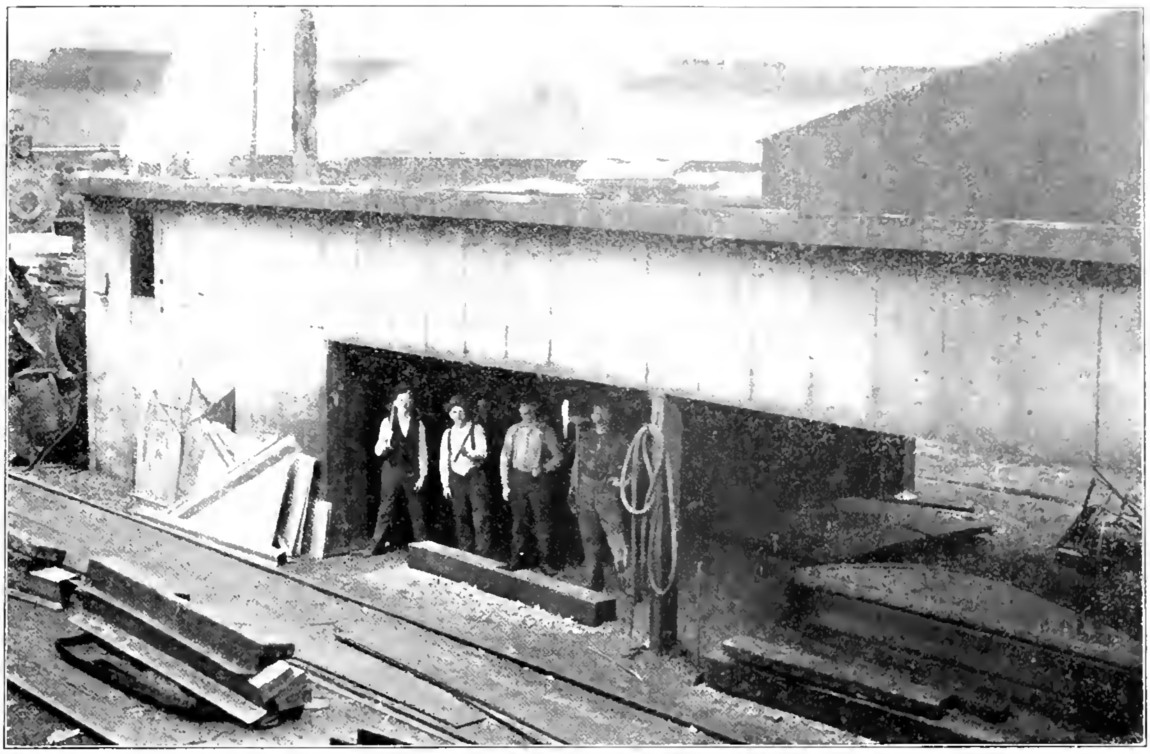

FIG. 13.—THE FLANGE FIRE SHOP.

iron. The sides are partially open, as shown. The equipment of this shop consists of an oil furnace, designed and constructed by the railroad, which will take material 10 ft. long and 6 ft. 4 in. wide. The furnace has an opening at one end only, but a new one which has recently been installed at Cumberland has doors at both ends so that long material, such as side and center sills, may be handled in it. A short distance in front of this furnace is an iron face plate 8 ft. 6 in. x 6 ft. 6 in. x 3 in. thick. As may be seen from the illustration, this plate was badly warped and was just about to be replaced by a new one. The screw press flange clamp, which is partially shown at the right side of the photograph, is used for clamping and flanging material and will take pieces 11 ft. wide. In addition, the shop is equipped with five formers, two of them for different classes of end sills, one of which is shown directly in front of the four men in the gang; a former for the hopper doors; formers for a side and center sill splice and also for a body bolster diaphragm. Only a few hand tools are required, such as tongs for handling the hot material and the wooden mauls and hammers for straightening the steel. The wooden mauls are of lignum vitæ, 5½ x 10 in., with 4 ft. handles.

FIG. 12.—"BOX JACK" FORCING THE SIDES OF A CAR OUTWARD.

The bent side and center sills are heated in a large open fire and straightened in the boiler shop, as the flange fire furnace is not long enough to handle them. Very few new steel parts are required for repairs. Splice plates for the center and side sills are made on the bulldozer in the blacksmith shop, and it is also intended to equip this machine with dies for making the cross braces which are shown in Fig. 24, and are used for stiffening the ends of the earlier types of gondola cars, in place of the angle iron vertical braces with which they are equipped. A 36 in. vertical drill is provided for drilling the holes in the splice plates and braces.

This is about all of the equipment that is required for carrying on the work and is very simple as compared to the tools required by the wooden car repairmen and a wood working shop, and the machine tools required in connection with it. The experience of the Baltimore & Ohio has demonstrated that under ideal conditions very little additional equipment would be required. In planning a new car repair plant to be built in the future, the repair tracks are spaced 20 ft. center to center, with material tracks between every other set of tracks, and possibly with a traveling crane extending over a couple of the heavy repair tracks, to be used largely in handling damaged cars and in taking out cars when repairs are completed. The flange shop will, of course, be considerably larger than the present one and will contain some additional equipment, but otherwise the facilities will not be much more elaborate than those at the present time.

Development in the Design of Steel Cars.

The leading argument advanced by the steel car builders when steel cars were first introduced was that they could be made much lighter than a wooden car of the same strength and capacity, and it was largely for this reason that the railroads decided to use them. It is not surprising, therefore, that some of the parts were made too light on the earlier cars. Due to the strengthening of these parts in the later designs the weight of the steel car has been increased so that, if anything, it is greater to-day than that of the wooden car of the same capacity. The railroads buy these cars not because they are lighter than the wooden cars, but because they are much more satisfactory from an operating standpoint. As the section dealing with typical repairs considers very largely repairs to the earlier classes of cars, it may be of interest to trace the development of those parts which have given the most trouble and show how they have been strengthened in the later cars. One feature of design which has much to do with the stiffening of the car and will greatly prolong its useful life is that the side sheets, which on the earlier cars were only about 3/16 in. thick, have been increased until now they are ¼ in. full. The floor sheets on the more recent cars are 5/16 in. thick. Other features of design, the development of which it will be profitable to study, are the center sills, especially that part between the bolster and the end sill; the body bolster construction and the end sills, more especially as concerns their reinforcement at the center where they come in contact with the coupler horn.

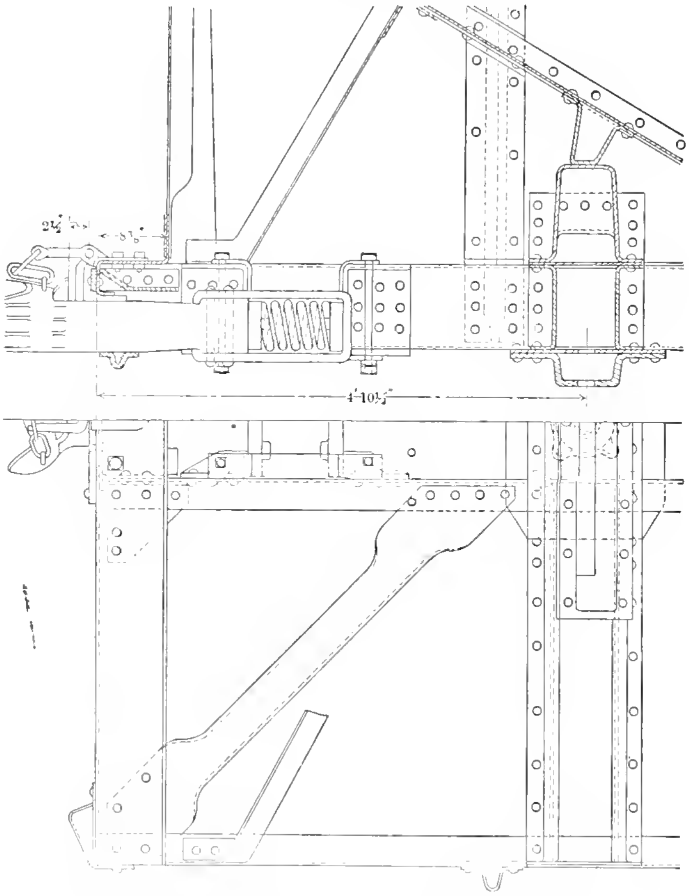

FIG. 14.—BODY BOLSTER, DRAFT SILLS AND END CONSTRUCTION OF THE FIRST ALL-STEEL HOPPER CARS (N-8).

Hopper Cars.—These features for the first class of hoppers, N-8, are illustrated in Fig. 14. The center sills are of pressed steel ⅜ in. thick and are continuous the entire length of the car. These cars were equipped with a twin spring draft gear, the draft lugs being of the well-known pressed steel type. As may be seen from the drawing, the center sills are not reinforced between the rear draft lug and the body bolster except by the diagonal braces which extend from the corner of the car to the center sill near the bolster. As the center sill at this point is only 10 in. deep and the flanges are about 4 in. wide the buffing shocks, which are taken entirely by the rear draft lugs, force the sills outward just back of the draft lugs and in many instances have cracked or broken them.

To strengthen the sills at this point and to facilitate making repairs the sills on the second lot of hoppers, N-9, were spliced,

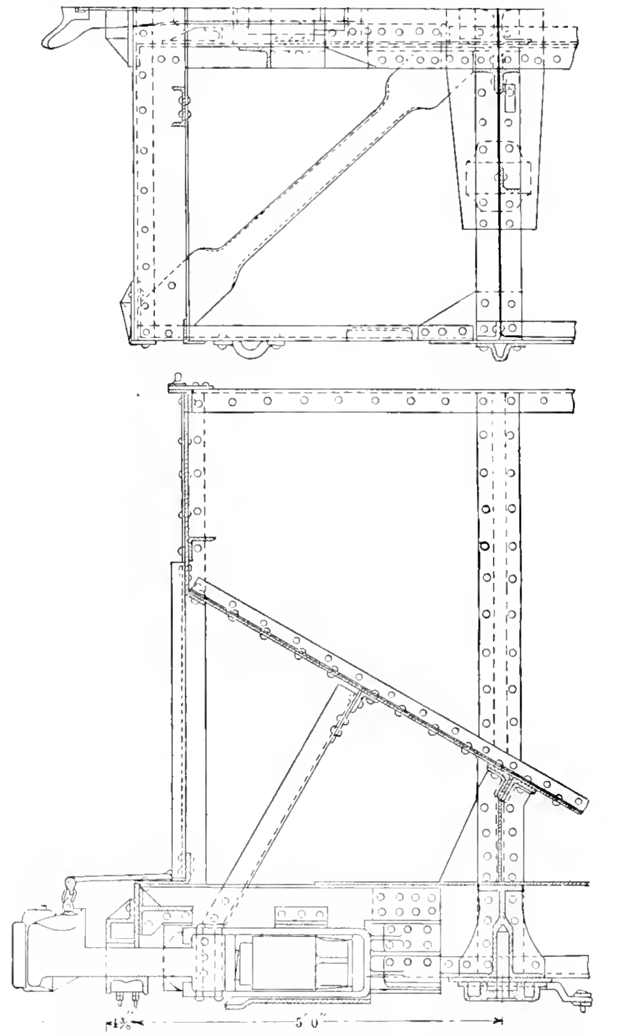

FIG. 16.—BODY BOLSTER, DRAFT SILL AND END CONSTRUCTION OF THE LAST LOT OF STEEL HOPPERS (N-10 AND N-10A).

as shown on Fig. 15, which also shows an application of tandem spring draft rigging. This draft rigging was applied to about 500 of the N-9 hoppers. The twin spring rigging, or the same as applied to the N-8, was applied to about 1,500 and friction draft gear to about 6,000. The reinforcement, due to the splice, stiffened the sills so that even with the twin spring draft rigging the trouble was considerably reduced, although the construction was still not as strong as might be desired. The construction on the latest hoppers, N-10 and N-10a, which were built in 1906, is very much stronger and it is expected that very little if any

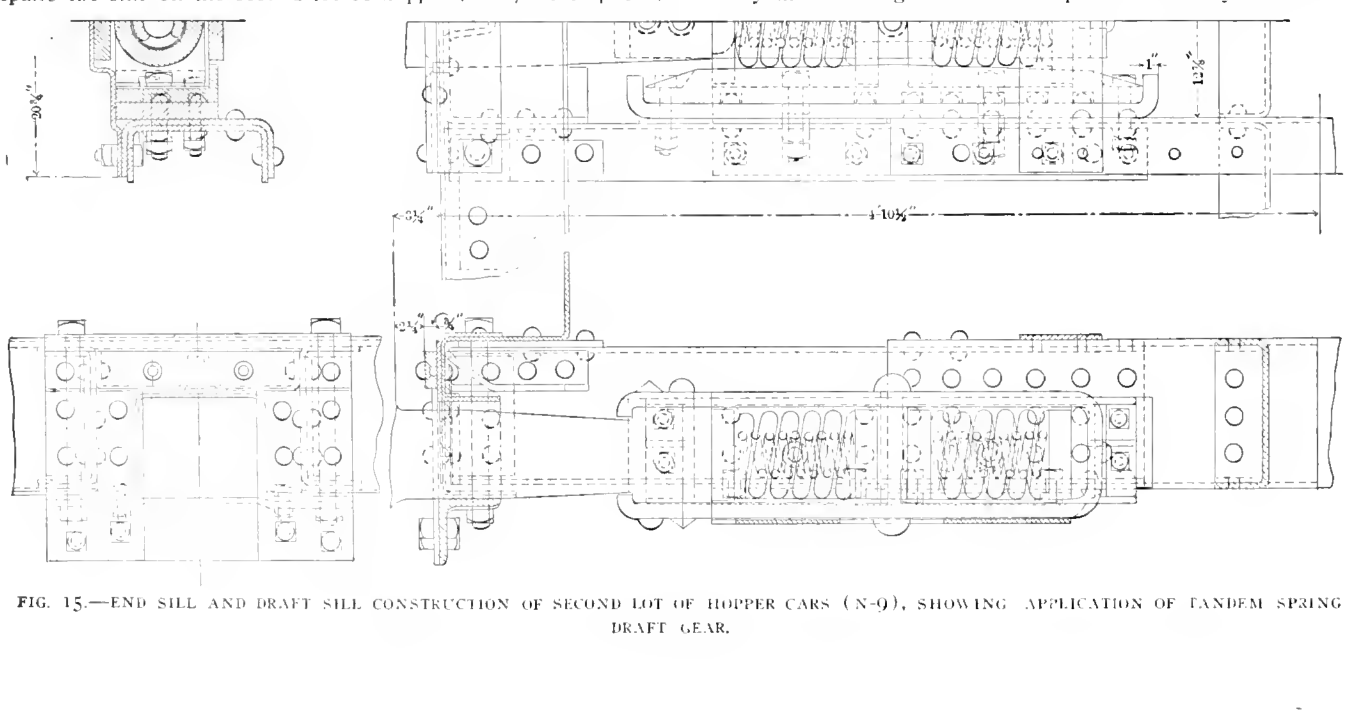

FIG. 15.—END SILL AND DRAFT SILL CONSTRUCTION OF SECOND LOT OF HOPPER CARS (N-9), SHOWING APPLICATION OF TANDEM SPRING DRAFT GEAR.

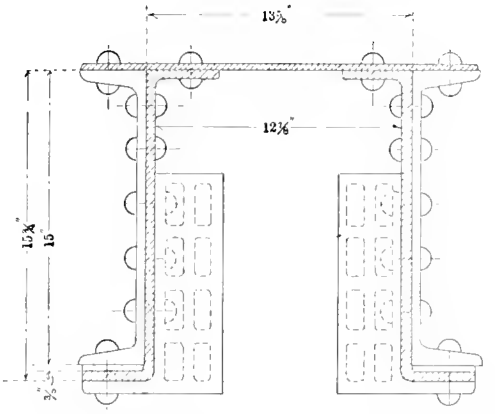

FIG. 17.—CROSS-SECTION OF EXTENSION CENTER OR DRAFT SILLS ON N-10 AND N-10A HOPPERS.

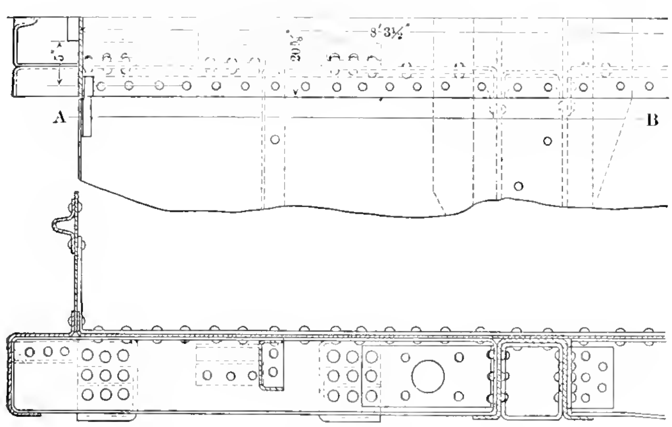

FIG. 20.—METHOD OF REINFORCING THE DRAFT SILL CONNECTION TO THE BODY BOLSTER ON CLASS O-12 AND O-14 GONDOLAS. (SEE ALSO FIG. 48.)

trouble will be experienced with them. This construction is shown in Fig. 16. The center sills are 15 in. channels reinforced at the lower inside edges by 3½ x 3½ x ⅜ in. angles. These angles extend through the body bolster to the rear draft lug. The sills are spliced by a pressed steel shape in the form of a Z, as shown on the drawing and in Fig. 17. This is 15¾ in. deep and is riveted to the web of the center sill channels by seventeen ⅞ in. rivets, also to the lower flanges of the channels and to the top cover plate. Friction draft gear is used and the draft lugs are of cast steel.

On the first two classes of hoppers, the N-8 and the N-9, the old type of pressed steel body bolster was used. This gave fairly good satisfaction except that that part between the center sills was hardly stiff enough to properly support the center plate. The bottom cover plates on the earlier cars were very light and on some of the later orders were increased in thickness, but even this did not give good satisfaction and on the latest cars a much stronger type of body bolster was used, as shown in Fig. 18. A heavy steel casting was placed between the center sills, forming a substantial support for the center plate. The section of the bolster is such that it is much stronger vertically than the older designs. The N-8 and N-9 hopper cars were equipped with pressed steel end sills, but these were changed on the N-10 and N-10a to a rolled channel. On class N-8 the striking plate consisted of a ¾ x 2½ in. bar, the only other reinforcement being the pressed steel shape, which was riveted between the center sills directly back of the striking plate, as shown on the drawing. The construction on the N-9 was quite similar except that a pressed steel shape was placed between the striking plate and the end sill, as shown in Fig. 15. This was somewhat more satisfactory than the earlier construction, but was superseded on the last lot of cars by a heavy steel casting, as shown in Fig. 16, which has thus far been very satisfactory. The carry iron on this later type of cars is also of cast steel. A few of these have been broken. The end sill is reinforced between the center sills by a steel casting.

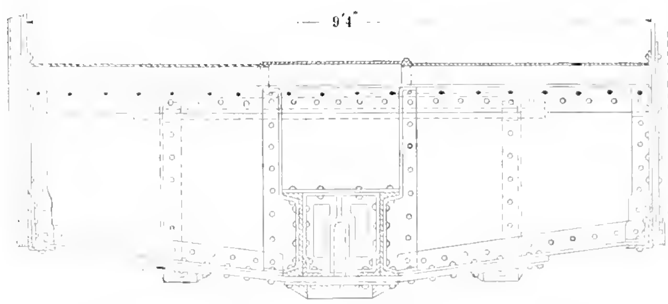

FIG. 18.—BODY BOLSTER ON LAST LOT OF HOPPERS (N-10 AND N-10A). SEE FIG. 16 FOR PLAN AND SECTION.

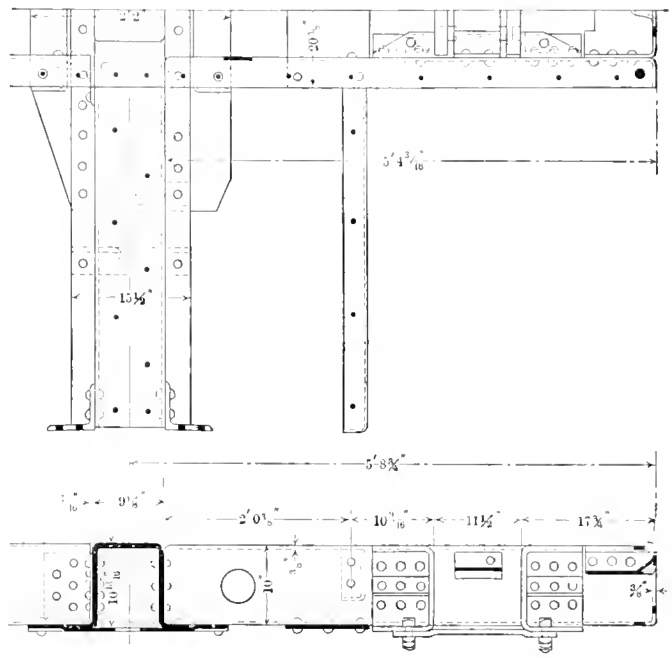

FIG. 19.—BODY BOLSTER, DRAFT SILL AND END CONSTRUCTION ON FIRST TWO CLASSES OF GONDOLA CARS (O-12 AND O-14).

Gondola Cars.—A somewhat similar development has taken place in connection with the gondola cars. The first two classes, the O-12 and the O-14, were very much alike. These cars were fitted with continuous body bolsters, as shown in Fig. 19, the extension center sills or draft sills being of pressed steel 10 in. deep with flanges about 4 in. wide. These sills were riveted to the bolster by three ¾ in. rivets and in addition were reinforced by a cover plate about ¼ in. thick and to some extent by the two pressed steel diaphragms, or cross braces, extending between the center and the side sills. This construction has not proved strong enough and when the cars come in for heavy repairs the draft sills are more securely fastened to the bolster by a ½ in. angle plate, and a ½ in. cover plate is applied in place of the lighter one, extending from back of the bolster to the end sheet and up on the end sheet a distance of 13¼ in. The method of repairing and reinforcing these sills is shown in Figs. 20 and 48. The same difficulty was experienced with the bolsters on these two classes of cars as on the earlier classes of hopper cars, the central portion not being stiff enough to properly support the center plate. The striking plate on the O-12 consisted of a ¾ x 2½ in. bar and was reinforced behind the end sill the same as on the N-8 hopper cars. On the second class of gondola cars a pressed steel plate was placed between the striking plate and the end sill, as shown on Fig. 21.

On the last class of gondola cars, the O-17, Fig. 22, the center sills were made continuous and consisted of a pressed steel shape reinforced at the lower inside edge by a 3½ x 3½ x ⅜ in. angle, which extended through the bolster to the rear draft lug. Between the center sills at the body bolster a steel casting was used somewhat similar to that one on the N-10 hopper cars. The construction of the center sills between the bolster and the end sill was also similar to that used on the hopper cars, as shown in Fig. 17, in that it consisted of a heavy Z-shaped pressed steel

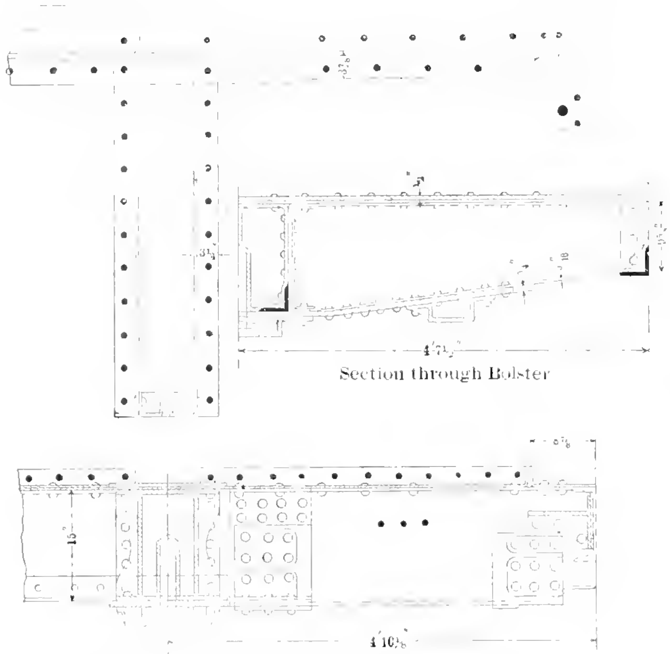

FIG. 22.—BODY BOLSTER AND DRAFT SILL CONSTRUCTION ON THE LAST LOT OF GONDOLA CARS (O-17).

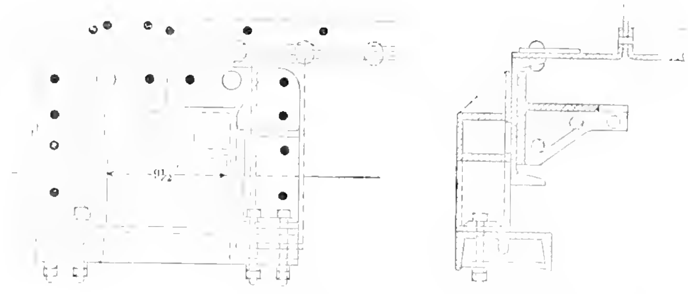

FIG. 23.—END SILL CONSTRUCTION AT STRIKING PLATE—O-17 GONDOLAS.

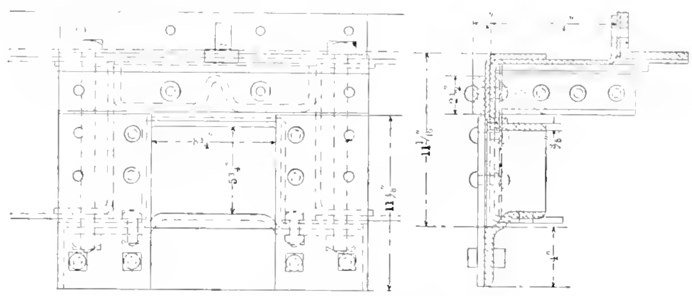

FIG. 21.—END SILL AND STRIKING PLATE CONSTRUCTION ON SECOND LOT OF GONDOLA CARS (O-14).

plate, 15¾ in. deep, which was spliced to the center sill. A steel casting similar to that used on the hopper cars, as shown in Fig. 23, was used for a coupler striking plate and a casting was also placed between the center sills, reinforcing the end sill at this point. The end sheets of the first two classes of gondola cars were stiffened by a couple of vertical angles, but these ends proved to be weak, and as the cars come in for heavy repairs the vertical braces are removed and replaced by heavy horizontal braces, the same as are used on the last lot of gondolas. One of the cars to which these braces were just being applied, in fact had not yet been riveted in place, is shown in Fig. 24. The twin spring draft rigging was used on the O-12 and friction draft gear on the O-14 and the O-17 classes, the O-17 having cast steel draft lugs.

Trucks.—On the N-8 hoppers and the O-12 gondolas the Schoen pressed steel truck was used, both the top and bottom arch bars being of pressed steel. This truck weighed about 6,960 lbs. On the first 2,000 of the N-9 hoppers the pressed steel truck having the top arch bar only of pressed steel was used. This

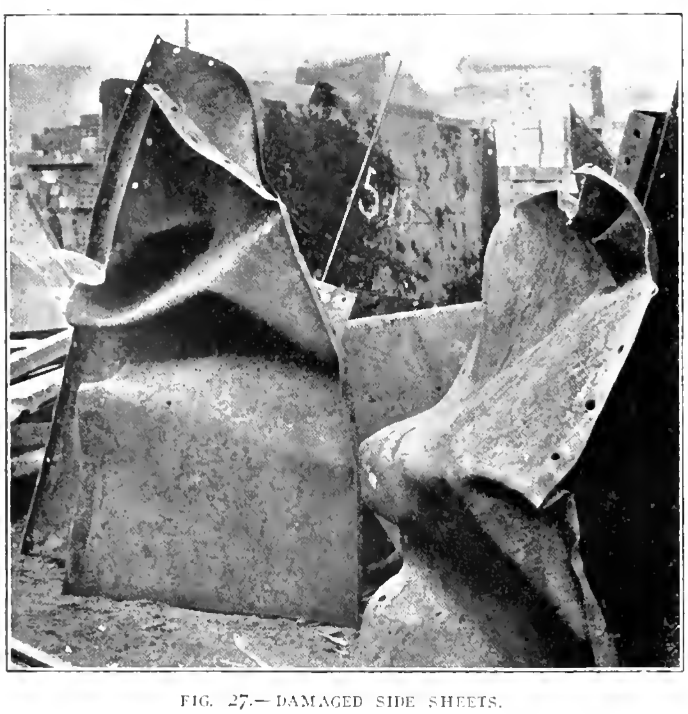

FIG. 27.—DAMAGED SIDE SHEETS.

truck weighed about 7,330 lbs. A similar truck was used on the first 3,000 cars of the O-14 class, which weighed 6,960 lbs. Seventeen hundred of the N-9 class were equipped with a lateral motion truck and the last 4,000 cars of that class were equipped with the diamond arch bar pressed steel truck. The last 1,000 cars of the O-14 class were equipped with a lateral motion truck. The last lot of gondolas and the last lot of hopper cars were

FIG. 24.—THE ENDS OF THE EARLIER GONDOLA CARS ARE BEING REINFORCED WITH HEAVY HORIZONTAL BRACES.

equipped with diamond arch bar trucks and structural type truck bolsters.

New Material Required for Repairs.

As will be seen from the section on typical repairs very little if any new material is required, no matter how bad the damage may be, except such as may be required for splicing the sills or other parts and patching the sheets. Most of the material used for patching is obtained from the locomotive boiler shop scrap pile. About the only materials used in addition to this are the rivets, the oil used in connection with the flange furnace fire and the air for the furnaces and the pneumatic tools.

The records show that in five years only one full length side or center sill has been ordered. In cases where the ends of the center sills, on the older cars, are broken off too near the bolster new pieces are required for replacing the end, but the longest of these is only 73 in. in length and can readily be made with very

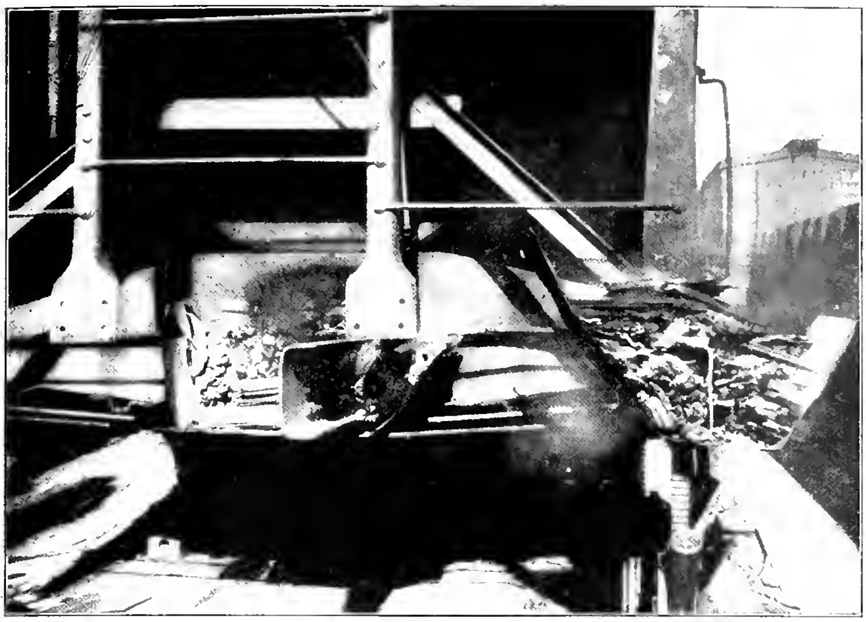

FIG. 25.—HEATING THE ENDS OF A SIDE AND TWO CENTER SILLS.

does not require his entire attention, and he assists the rest of the gang while the iron is being heated. In the freight car repair yard there is plenty of scrap wood, so that the fuel costs nothing.

Fig. 25 shows one of these hopper cars with the end of one side sill and the two center sills being heated. The center sill to the left has been broken off and the broken end will have to be straightened so that it can be spliced. When the different parts have become sufficiently heated the jack is lowered and the sheet iron, with the fire on it, is lifted to one side and the sills are straightened with hammers. To space the sills the proper distance apart a wooden templet is bolted to the top flanges at the ends after the sills have been heated and pulled into place. The sills are shown after they have been straightened in Fig. 26. The heavy iron bar at the right is used as a ram in helping to straighten the center sills.

If the side sheets are bent, but are not injured sufficiently to remove them from the car, it is the usual custom to take the

FIG. 28.—A TORN AND BENT SIDE SHEET AWAITING REPAIRS.

FIG. 26.—THE SILLS SHOWN IN FIG. 25 AFTER THEY WERE STRAIGHTENED.

box jack, shown in Fig. 12, and support the wooden end of it on blocking near the juncture of the hopper and side sheets and have the other end screwed tight against a block near the distorted part of the sheet. The sheet can then easily be hammered into shape.

simple dies. As far as can be ascertained it has never been necessary to order any of the large side sheets, for no matter how badly they have been bent or torn they can always be patched up in good shape.

Straightening Material in Place.

Damaged parts are often straightened without removing them from the car. When the center sills on the hopper cars are bulged out just behind the rear draft lug it is necessary to straighten and reinforce them. Usually, in cases of this kind, the end sill is damaged so that it has to be removed and the end of the side sills are also damaged. A piece of galvanized iron from an old car roof is placed on top of a jack, placed underneath the damaged part, and a fire is built on it underneath and around the damaged member. The fire underneath the center sills in the accompanying illustration is carried on the two rods whose ends are supported on the side sills. One of the men in the gang is detailed to build the fire and attend to it, but this

Some Typical Repairs.

As may be seen from the following illustrations and description of typical repairs which are being made at the Mt. Clare shops, the work is simple, very little special equipment is required and very little new material is used. No matter how badly a sheet is damaged it can usually be straightened and repaired at a comparatively small cost. Badly bent and torn side sheets are shown in Figs. 27 and 28, waiting to be straightened at the flange shop. The method of straightening sheets of this kind on the face plate with wooden mauls is shown in Fig. 29. After the sheet has been approximately straightened the smaller kinks are removed with iron hammers. When the sheets are torn a patch of 1/4 in. material, cut to approximately the shape of the tear, is placed on the outside of the car and riveted with 5/8 in. rivets spaced about 4 in. apart. The side and center sills are straightened at a large open fire in the boiler shop. A number of damaged sills waiting to be straightened are shown in Fig.

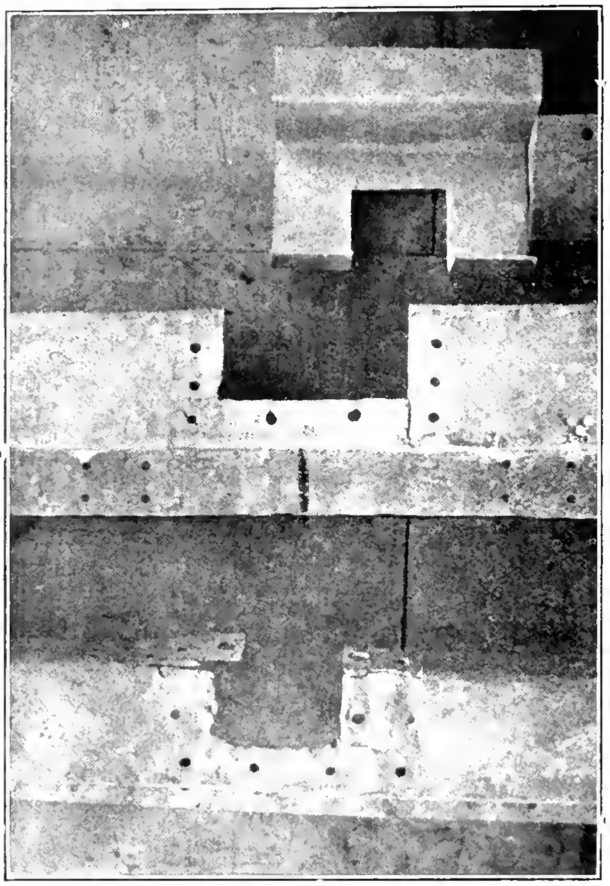

FIG. 33.—DAMAGED END SILLS AFTER BEING STRAIGHTENED; ALSO THE REINFORCING PIECE FOR THE CENTER.

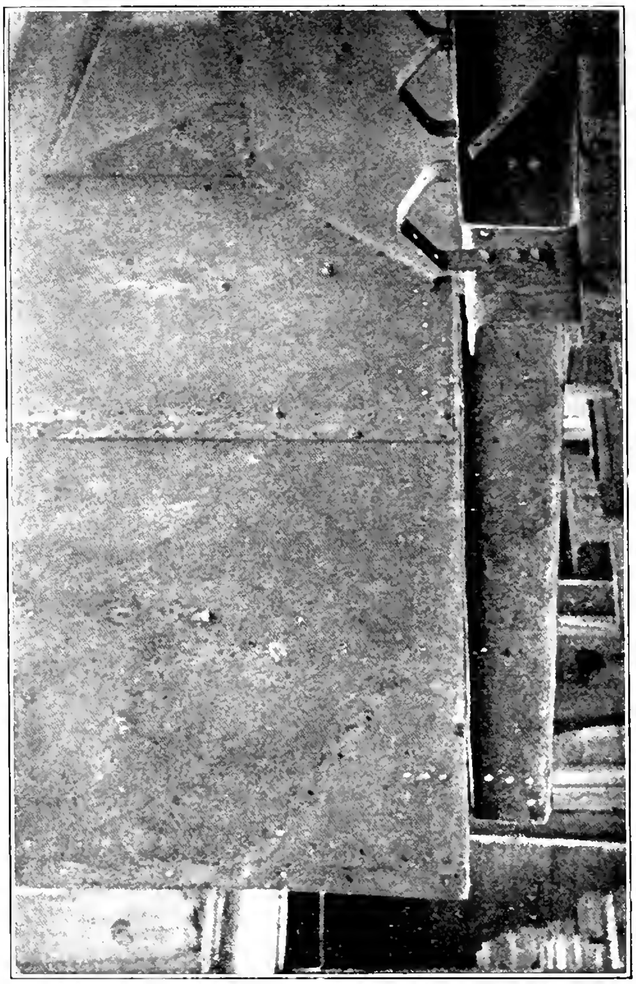

FIG. 36.—CENTER SILLS ON A HOPPER CAR BROKEN BACK OF THE BODY BOLSTER AND A SIDE SILL BROKEN AT THE BOLSTER.

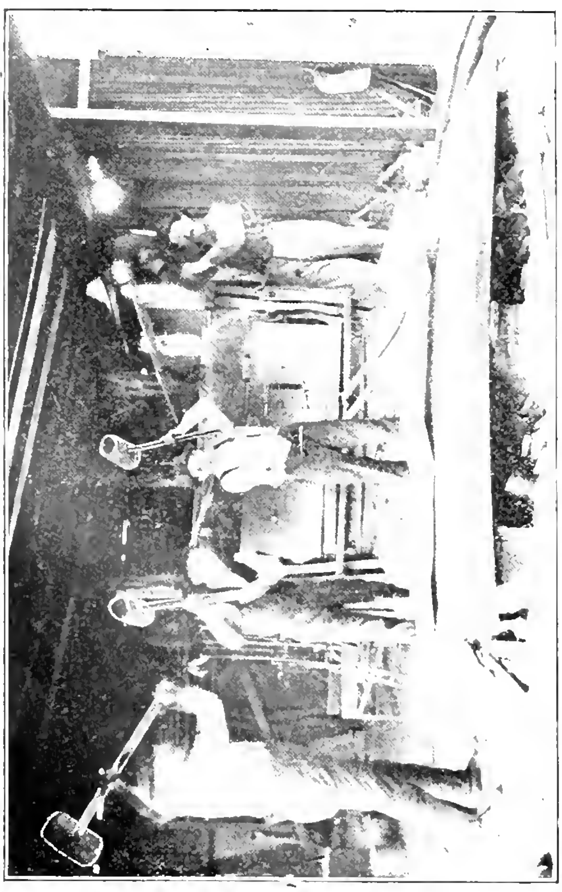

FIG. 29.—STRAIGHTENING A BENT SHEET IN THE FLANGE SHOP.

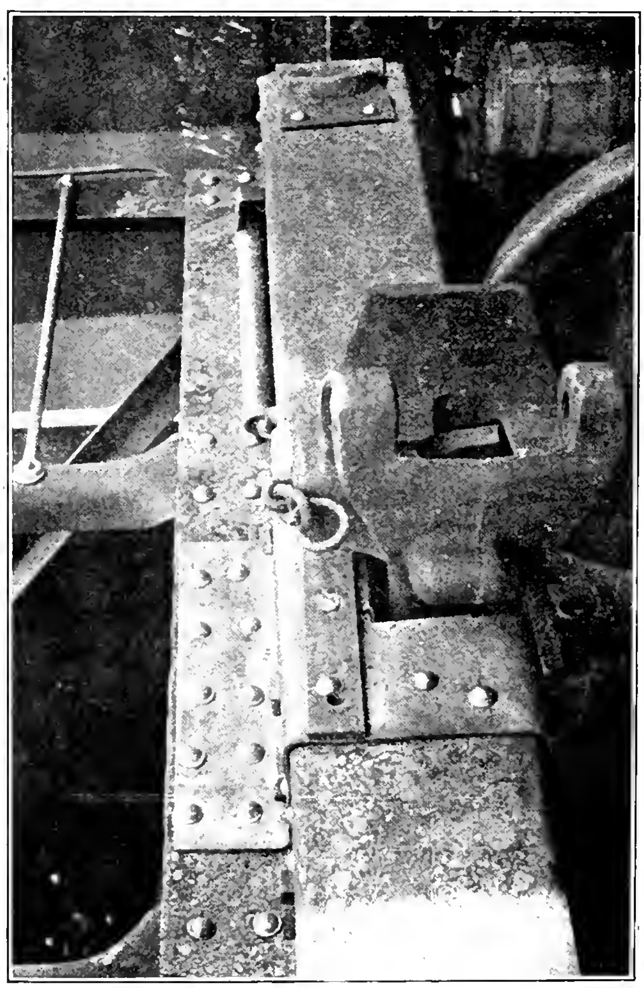

FIG. 34.—DAMAGED END SILL REPAIRED AND IN PLACE ON THE CAR.

FIG. 30.—DAMAGED SIDE AND CENTER SILLS.

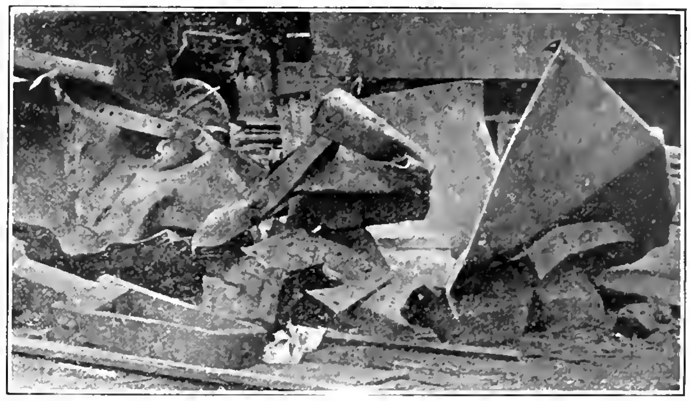

FIG. 31.—BADLY DAMAGED END SILL AND SHEETS.

FIG. 32.—BENT AND TORN END SILL.

30. These sills can easily be straightened and if they are cracked or broken can readily be spliced.

Hopper Cars.—Probably the greatest trouble that is experienced with the older hopper cars is the crushing of the end sills. An end sill that has been badly damaged is shown in Fig. 31, and one which has been torn and was just about to be taken into the flange shop for straightening is shown in Fig. 32. These sills are placed in the furnace and heated and then hammered approximately into shape on the face plate, straightened in the screw press and finally shaped accurately on a former provided for that purpose and shown just in front of the men in Fig. 13. A couple of these end sills that have just been straightened are shown in Fig. 33. When the sills are cracked or torn, as shown in the illustration, the reinforcing piece at the right is placed over them at the center. This piece is quite similar to that used on the N-9 hoppers except that the top flange extends upward and is riveted to the end sill by the ten additional rivets, as shown in Fig. 34, which shows one of these repaired end sills in place on the car. The cost of removing, straightening and replacing one of these sills is not very great, as may be seen by referring to the section on the comparative cost of repairing steel and wooden cars.

The center sills on the N-8 hoppers are often broken back of the draft lugs and in some instances have been broken back of the bolster. If the sills are broken back of the rear draft lugs and at least 8¾ in. from the bolster, as shown in Fig. 35, the old piece is spliced to the sill, as shown. If the break is back of the bolster and at least 8¾ in. from the bolster, as shown on the diagram, the old piece is spliced on. If the sills are broken between the draft lugs it is necessary to cut the sill 8¾ in. in front of the bolster and splice on a new piece, or if the sills are broken on either side of the bolster and less than 8¾ in. from it a new piece either 43 in. or 73 in. long, depending on which side of the bolster the break is, is spliced to it.

A car that was badly damaged and had both of the center sills broken back of the bolster and both of the side sills broken at the bolster is shown in Fig. 36. A ⅜ in. plate 22½ in. long is riveted on the inside of the center sill and a ⅜ in. piece of the same length, of channel shape, formed to fit snugly inside of

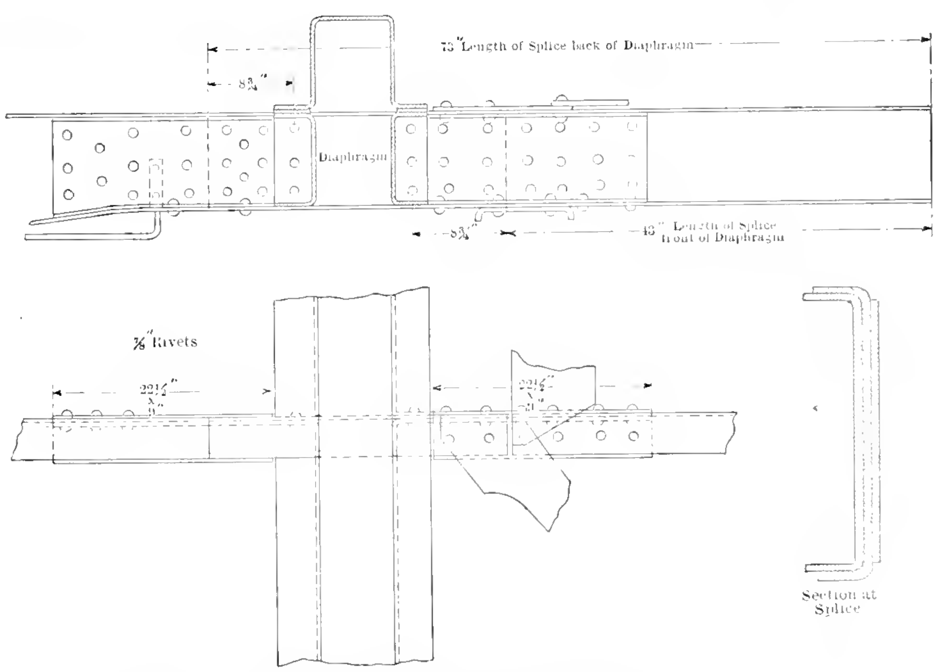

FIG. 35.—METHOD OF SPLICING CENTER SILLS BOTH IN FRONT AND BACK OF THE BOLSTER ON CLASS N-8 HOPPERS.

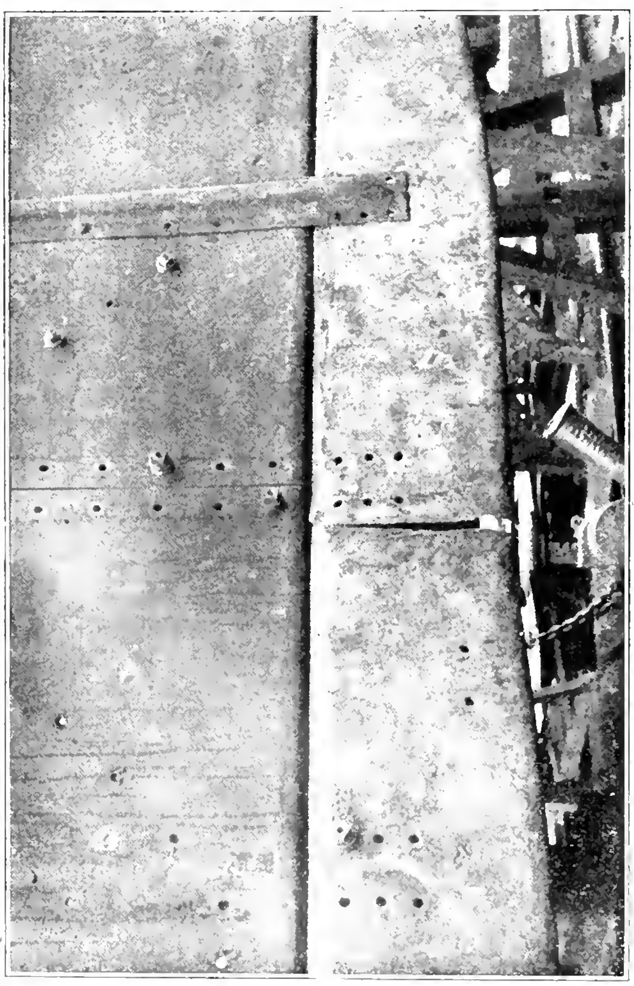

FIG. 41.—SIDE SILL OF HOPPER BROKEN NEAR THE CENTER OF THE CAR.

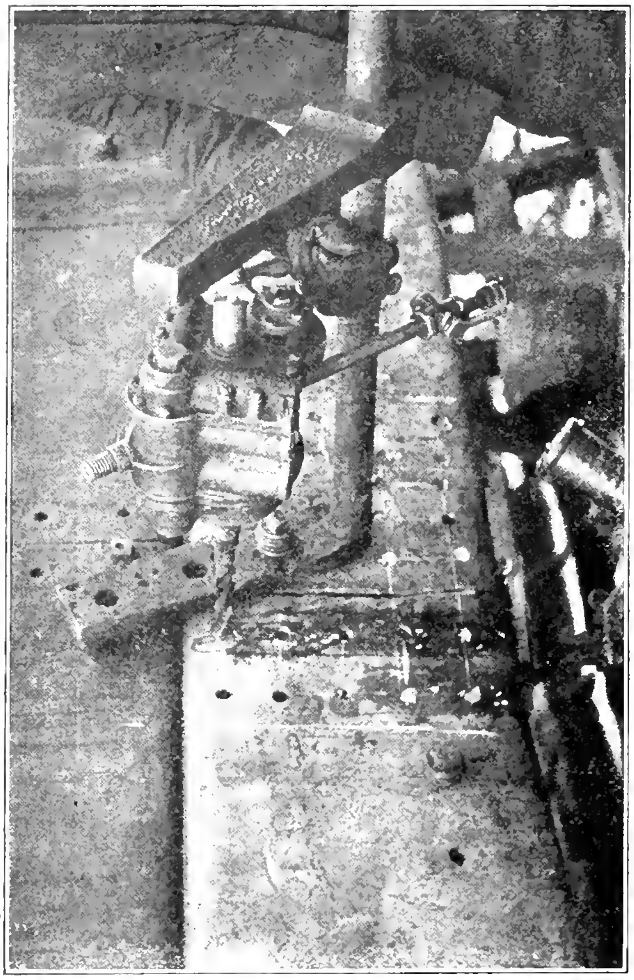

FIG. 42.—DRILLING HOLES FOR THE SIDE SILL SPLICE WITH A PNEUMATIC DRILL.

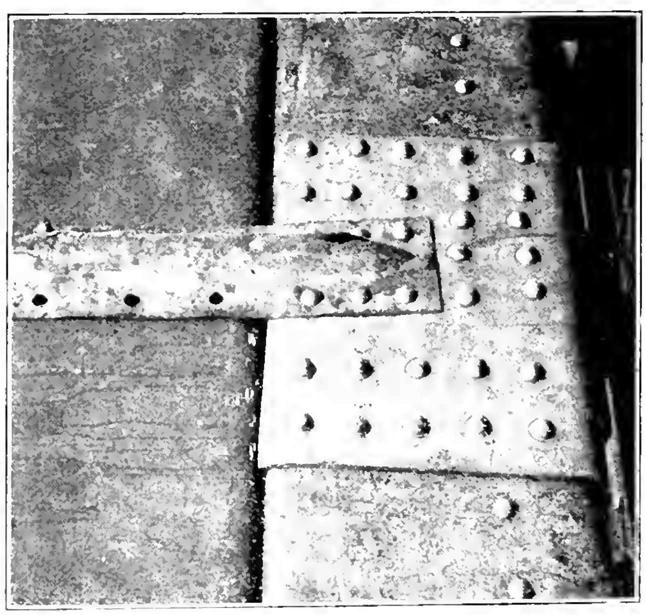

FIG. 43.—FINISHED SPLICE ON SIDE SILL.

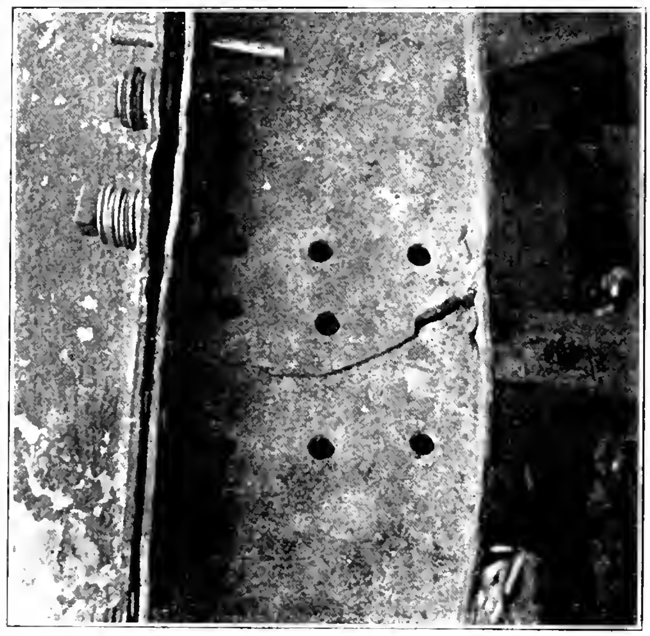

FIG. 44.—TORN BODY BOLSTER DIAPHRAGM.

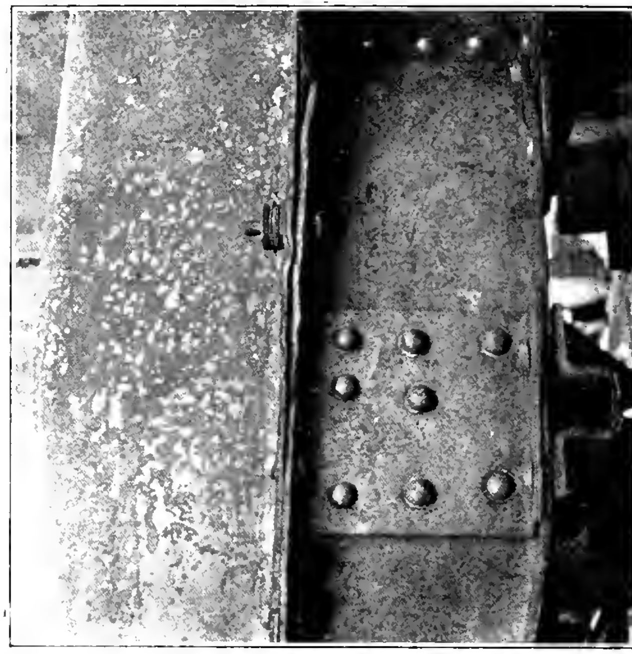

FIG. 45.—PATCH ON BODY BOLSTER DIAPHRAGM.

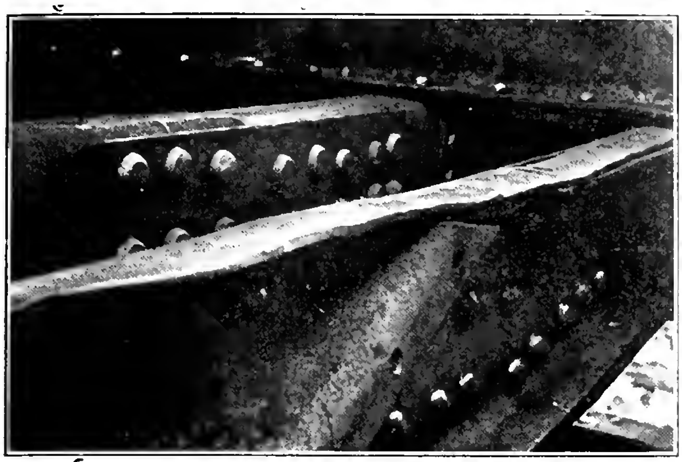

FIG. 37.—TWO BROKEN CENTER SILLS SPLICED BACK OF THE BOLSTER. (SEE FIG. 36.)

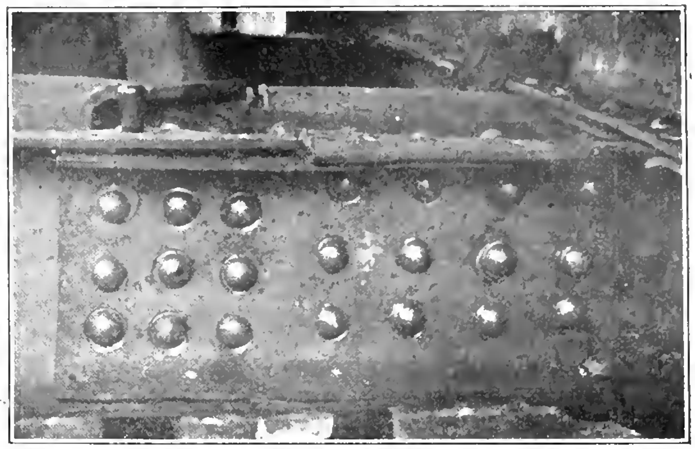

FIG. 38.—CENTER SILLS ON HOPPER CAR SPLICED IN FRONT OF THE BOLSTER AND AT THE REAR DRAFT LUG.

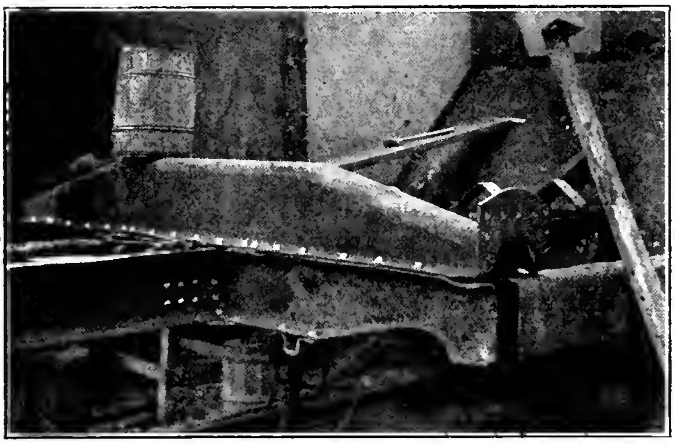

FIG. 39.—HOPPER CAR SIDE SILL BROKEN AT THE BOLSTER.

the center sill, is riveted to the outside. The flanges of the reinforcing channel are fastened to the sill by two rivets on either side of the break at both the top and bottom. A photograph of one of these splices is shown in Fig. 37. The work had not been quite finished when the picture was taken and the holes for the rivets in the top and bottom flanges had not yet been drilled.

The method of splicing the center sills between the bolster and the end sill is quite similar. A photograph of one of these splices is shown in Fig. 38. In this case the holes had been drilled through the flanges for the rivets, but they had not yet been driven. Both of the center sills were broken. The break was directly back of the rear draft lug and the reinforcing plate was made long enough to extend to the front end of the lug.

Side sills broken at the body bolster are shown in Figs. 36 and 39. The latter photograph gives a good idea of the bolster construction on the older hoppers. The method of making the splice is a simple one and is shown in Fig. 40. These cars have a ⅜ in. plate, used to stiffen the side of the car at the bolster for jacking purposes, but which does not have the flange extending underneath the sill. When the sills are broken at this point the old plate is scrapped and a new one, similar to the one shown in the illustration, is used. The only additional rivets required are the two at the lower flange and the four indicated by arrow heads in the illustration.

Occasionally the side sills may be broken between the two bolsters. A broken sill of this kind which had been badly buckled and is shown after it had been straightened and while the car was being re-assembled is illustrated in Fig. 41. A ⅜ in. plate was placed on the inside of the sill and a ⅜ in. plate, flanged at the lower end, and extending under the sill, was placed on the outside. Fig. 42 shows the method of drilling the holes in the sill for these splice plates. An "old man" or brace was fastened in place and the holes were drilled with a pneumatic drill. A view of the finished splice is shown in Fig. 43.

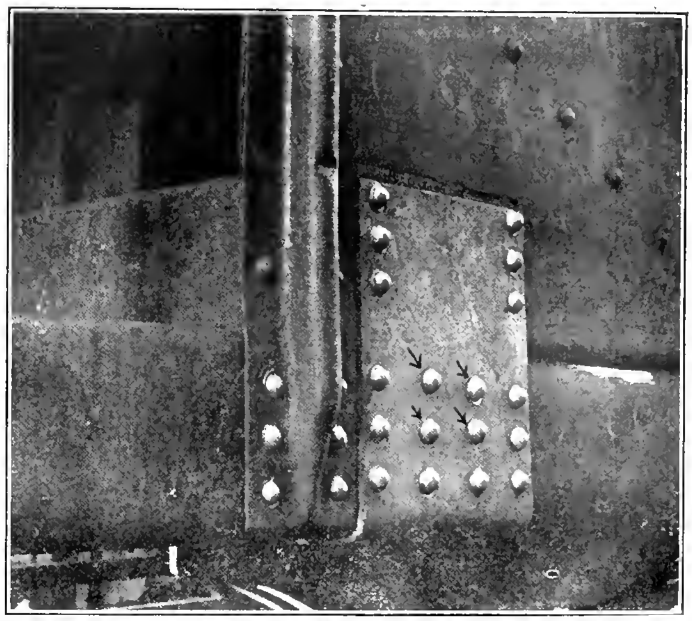

FIG. 40.—BROKEN SIDE SILL, SHOWN IN FIG. 39, SPLICED.

A body bolster diaphragm that had been torn is shown in Fig. 44. This was repaired by riveting on a plate ⅜ in. thick and 10 in. wide, Fig. 45.

Gondola Cars.—The method of stiffening the end sheets on the O-12 and O-14 gondolas has already been mentioned (page 166). The greatest difficulty encountered with these cars is the tearing away of the extension center sills, or draft sills, from the body bolsters. These draft sills are attached to the bolster by three rivets at the vertical portion and one rivet through the lower flange of the bolster. In addition they are held to the bolster cover plate by one rivet. The way in which the sills are torn from the bolster is illustrated in Figs. 46 and 47. As has been stated (page 165), in repairing damages of this kind the top cover plate on these cars is removed and replaced with a ½ in. plate which extends from the hopper opening to the end of the car and up on the end 13¼ in. to take the rivets in the bottom edge of the lower of the two cross braces, which are being applied to these cars as they come in for heavy repairs. The old cover plate was only ¼ in. thick and the rivets were spaced about 9 in. apart. The new ½ in. plate has rivets spaced about 4½ in. apart. The fastening of the sills to the bolster is reinforced, as shown in Figs. 20 and 48. The sill is bolted to the bolster, because it is impossible to drive rivets.

Very few of the last lot of gondola cars are to be found on the repair track. The writer was able to find only one, during his visit to Mt. Clare, and this had the lower flange of one of the center sills and the cross braces between the center sill and the side sill more or less damaged, although the rest of the car was uninjured. A view looking along the lower edge

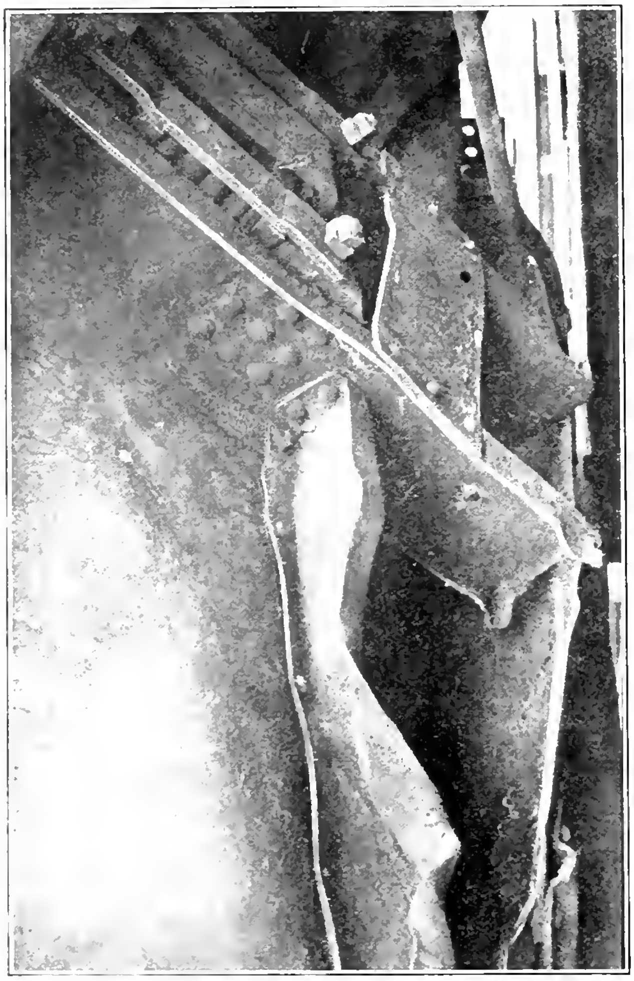

FIG. 47.—ANOTHER EXAMPLE OF DRAFT SILLS TORN FROM BODY BOLSTER ON GONDOLA CAR.

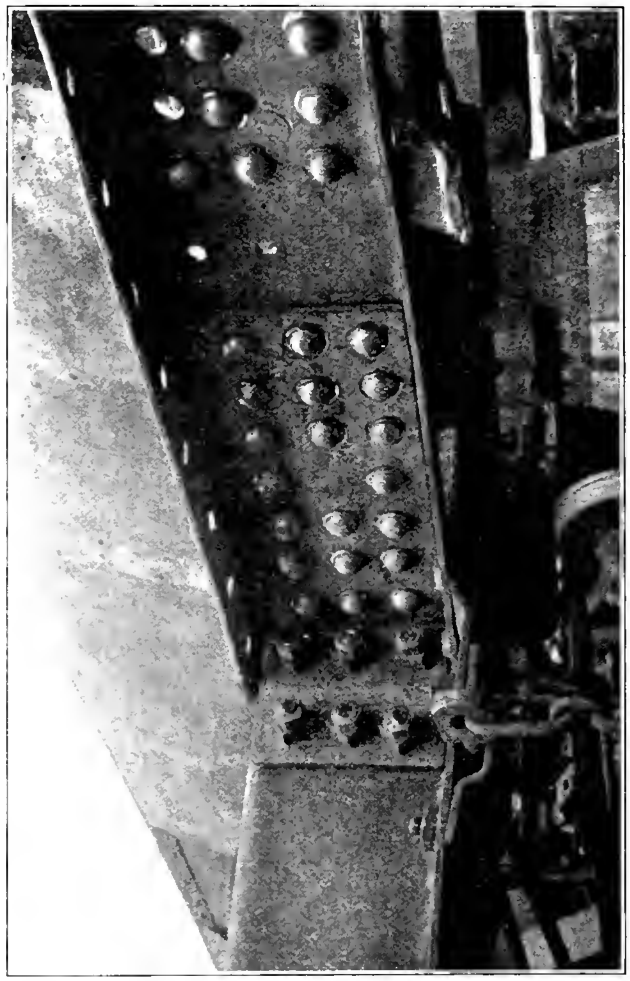

FIG. 48.—DRAFT SILL ON GONDOLA CAR REPAIRED AND REINFORCED. (SEE ALSO FIG. 20.)

FIG. 46.—DRAFT SILLS TORN FROM THE BODY BOLSTER ON O-12 GONDOLA CAR.

of this damaged center sill is shown in Fig. 49. The sill was removed and straightened. To do this it was necessary to remove the floor plates and loosen the sill from the cross braces and bolsters and drop it out, the sides of the car remaining intact.

Occasionally a car is damaged and the underframe is sprung out of shape so that two of the diagonally opposite corners are higher than the other two. In cases of this kind the high corners are connected to the rail by a ratchet pulling jack and are pulled down until, when released, the four corners are on a level.

Cost of Repairing Steel and Wood Cars.

The following figures are presented to briefly convey some idea as to the comparative cost of repairing steel and wooden cars.

Removing and replacing a damaged end sill on a steel car:

Labor	$3.97
Material	.52
Total	$4.49

Removing and renewing a damaged end sill on a wooden car:

Labor	$0.95
Material	3.78
Total	$4.73

* * * * * * *

Removing an end sill and repairing the draft on a steel car:

Labor	$10.33
Material	1.08
Total	$11.41

This figure assumes that the center sills were bulged out and would have to be heated and bent back into place.

Cost of repairing center sills between the body bolster and end sill on a steel car:

Labor	$18.62
Material	3.53
Total	$22.15

These figures are based on the assumption that

both of the center sills were broken and required splicing and that the end sill was taken off and straightened.

Cost of repairing the center sills, including a defective end sill, and the draft gear on a wooden car:

Labor	$10.22
Material	19.86
Total	$30.08

This figure is based on the assumption that new center sills and end sills would have to be furnished on the wooden car. In cases of this kind, adjacent parts are usually damaged, but this has not been taken into consideration in making up these figures.

* * * * * * *

Repairing side sill bent near the end sill on a steel car:

Labor	$1.17
Material	0.05
Total	$1.22

Splicing a side sill near the end sill on a wooden car:

Labor	$1.28
Material	0.78
Total	$2.06

Ordinarily a steel car in this condition would not have to go in for repairs until some other part was injured, but the side sill on a wooden car would probably be splintered and other parts damaged.

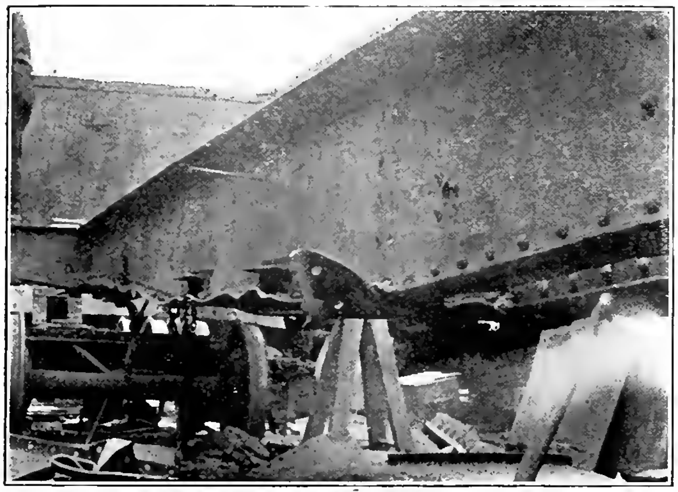

FIG. 49.—LOWER EDGE OF CENTER SILL DAMAGED ON CLASS O-17 GONDOLA CAR.

* * * * * * *

Splicing a side sill at the bolster on a steel car:

Labor	$3.53
Material	0.63
Total	$4.16

Splicing a side sill at the bolster on a wooden car:

Labor	$2.87
Material	3.02
Total	$5.89

* * * * * * *

Cost of repairing or splicing a side sill on a steel car, both ends:

Labor	$7.06
Material	1.26
Total	$8.32

Cost of removing and renewing side sill on wooden car. This would be necessary if both ends were damaged as on the steel car above:

Labor	$5.25
Material	6.52
Total	$11.77

* * * * * * *

The following figures are for repairing one of the worst damaged hopper cars. It was one of class N-9. The sills were spliced in eight places and the sheets were patched in eleven places. The car had to be practically cut to pieces, the various parts straightened up, repaired and re-assembled.

Cost of repairing the body was:

Labor	$190.00
Material	38.83
Total	$228.83

Trucks:

Labor	$2.70
Material	16.40
Total	$19.10

The labor cost for repairing badly damaged steel cars usually runs from about $100 to $175 per car.

* * * * * * *

A study of the above figures will give an idea of the relatively small amount of new material which is required for repairing steel cars as compared to wooden cars.

Painting.

The present practice on the Baltimore & Ohio is to, as far as possible, repaint the steel cars at regular intervals, but the equipment is so large and the demand for cars has been so heavy during the past three or four years that many of them have been in service for seven or eight years without repainting. It is even a question as to whether the increased life due to repainting will be great enough to offset the cost of keeping the car out of service, under present conditions, long enough to repaint it. There is also a question as to just how often a steel car should be repainted in order to give the best result from the standpoints of increased life and service requirements. The damage to the outside of the car due to corrosion is very slight, the greater difficulty being with the inside. An ordinary paint placed on the inside will be entirely obliterated in six months or less, and certainly it would hardly be advisable to take the car out of service every six months to paint the inside of it. A special paint is needed for this purpose, although the conditions to be met are so severe that it is doubtful whether it will be possible to get a covering that can withstand them for any great length of time. The underframe is not exposed to moisture and it is questionable if it will pay to repaint it at all after it has come from the builder. As these cars can be painted only during the months from May to November, it is rather a difficult problem to take care of a large equipment and keep it in first-class condition as far as appearance is concerned.

Practically the only painting that really accomplishes any very great results, as regards preserving the metal, therefore, is that which is applied when the cars are first built. As is well known the metal aprons on coaling trestles which are out of use corrode very rapidly, while those installed at the same time, but which are in constant use, last until the metal is actually worn out by friction. The same thing will, of course, apply to steel cars, and it would seem that the best results could be obtained by keeping the cars constantly in service. It would also appear that for this reason the flat bottom cars would be in greater need of a protective coating on the interior since the friction due to loading and unloading is much less than on the hopper cars.

The following extracts from the Baltimore & Ohio specifications for painting the new all-steel cars are of interest:

Before painting metal parts, all rust and scale must be thoroughly removed by the use of scrapers and wire brushes, or sand blast, and all oil and grease thoroughly removed by the use of benzine so that all parts to be painted have a thoroughly clean metal surface. The first coat is to be applied immediately, before additional rust or dirt forms on the surface. All parts where metal is placed on metal and either riveted or bolted must be plastered with pure red lead mixed in raw linseed oil to the consistency of putty before assembling and after assembling all crevices must be thoroughly filled with the same mixture.

The painting is to be done with a hand brush not over 6 in. wide and not more than one coat is to be applied in each twenty-four hours. The body and underframing are to be given three coats, the first one of black, the second one of Baltimore & Ohio freight car paint, which is red, and the third one of black.

Three coats, two black and one red, are used for two purposes. In the first place the combination of the black coat, the coloring being of lamp black, which is fine, and a red paint, which contains iron oxide, which is very coarse, seems to give much

better results than where all the coats are of black or all of the red paint. The different colored coatings also make it possible to check the number of coats with greater accuracy.

For repainting steel cars only one or two coats of paint are used. The cars are cleaned with wire brushes and scrapers, and if heavy repairs have been made a coat of red freight car paint is first applied and then a coat of black. If light repairs are made, or if the cars require repainting only for the purpose of maintaining the appearance and preserving the identity, only the one coat of black paint is applied. This class of painting is frequently done when cars are held under load in transportation yards and on coaling trestles, so that the car is not held out of service unnecessarily.

The specifications for the first coat of paint are as follows:

10 gal.	semi-paste paint	68.8 per cent.
5 "	raw linseed oil	16.1 " "
5 "	japan oil	15.1 " "

(Pigment in mixture—48 per cent.)

The specification for the semi-paste paint is as follows:

Freight car paint must be furnished in the semi-paste form, containing about 70 per cent. of pigment, and between 28 and 32 per cent. of pure raw linseed oil, with no admixture of rosin oil, petroleum products, or adulterants of any kind.

The pigment must be at least 35 per cent. pure oxide of iron, and contain not less than 2 nor more than 5 per cent. calcium carbonate. It must contain only such inert matter as occurs with it in nature, with no addition of barytes, aniline colors, lakes or any other organic coloring matter, no caustic substances or other ingredients, except calcium sulphate fully hydrated and silica.

The pigment must be so finely ground that when thinned with pure raw linseed oil, as shown in the following test, the opaque mass must not have settled down more than 1¾ in. in three hours, with no separation of coarser particles at the bottom. Take a ⅝ in. test tube and fill with pure raw linseed oil to a height of 4½ in., then add the semi-paste until the height of the oil is 5 in. from the bottom, cork, shake well, and stand in an inverted vertical position for three hours, the temperature being 70 degs. F.

The specifications for the coat of black are as follows:

1 lb. Germantown lamp black, dry.
2 lb. semi-paste paint, as above.
⅝ gal. raw linseed oil.
⅝ gal. japan oil.

This paint to be mixed and allowed to soak at least twenty-four hours before it is used.

LOCOMOTIVE PISTON VALVES.

By Hal. R. Stafford.*

The locomotive is indebted to the marine branch of steam engineers for more than one great improvement. Next in importance to the principle of compounding, in the opinion of many, is the use of the piston valve, or "piston slide valve" as we have been taught to say. In this description the former term will be used.

The Piston Valve in Marine Practice.—Although its advantages of simplicity and perfect balance were early recognized, its adaption in marine practice does not seem to have come about through the recognition of any inherent merit, but in the words of an ex-marine engine designer, it was only used "as a subterfuge for a slide valve, when such a valve would be so large as to be unwieldy and difficult to balance."

Historical.—While this article is not intended to be historical, a brief account of the earlier applications of the piston valve to the locomotive would seem essential. Probably its first application to locomotive work was made by Mr. T. B. Henney, then superintendent of motive power of the New York & New England Railroad, who tried some experiments with piston valves (see American Engineer and Railroad Journal, October, 1904, p. 384) as applied to simple engines, but without any marked success, because of the use of too small a valve. About this time also the Vauclain compound locomotive having a piston valve appeared. As it performed the function of distributing steam to two cylinders, the reason for its application in this case is obvious, since the use of a slide valve would have been almost a mechanical impossibility.

For its earliest successful application to simple engines, we are mainly indebted to Mr. John Player, and the Brooks Locomotive Works, of which he was then mechanical engineer, although mention must be made of its application to a single engine on the Norfolk and Western soon after this, by Mr. G. R. Henderson. Most of the early investigation and exploitation of the piston valve engine, however, was the work of the Brooks Works, which for a long time was almost alone in the field.

The application of piston valves by this company dates from 1889, although these first engines were really slide valve engines, with a cage containing the valve fitted into a peculiarly shaped steam chest. This arrangement shows much ingenuity, since the whole cage and valve were arranged to lift inside the chest, to give relief in the same manner as the slide valve. It was not until several years later that the Brooks Works commenced building bona-fide piston valve engines, which became increasingly popular.

Those concerns interested in cross-compounds soon adapted the piston valve for the high-pressure cylinder, because of the difficulty experienced in balancing the large slide valve necessary against the high pressure used. These valves were of the outside admission type, because the low-pressure slide valve was necessarily so, and it was desirable to maintain the valve gears the same for both sides. Until the direct motion was introduced, many simple engines were built with outside admission, which were more or less unsuccessful.

Packing.—With the exception of the piston valves built at the Brooks Works, all early valves on simple or two-cylinder compound locomotives were of solid one-piece construction, with

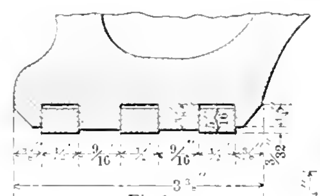

Fig.1

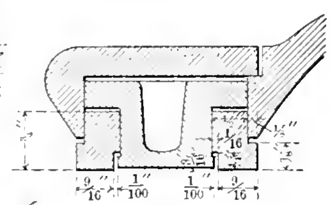

Fig.4

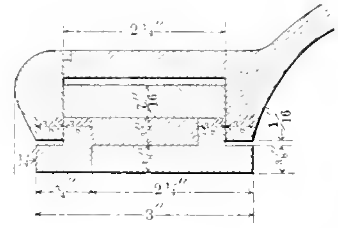

Fig.2

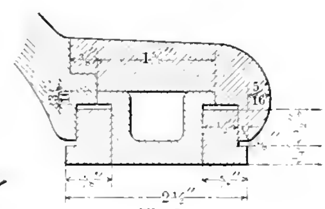

Fig.5

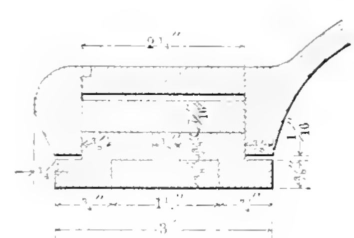

Fig.3

closed ends—that is, there was no communication between the opposite ends through the valve body—while for packing the ordinary piston snap ring of rectangular section sufficed (Fig. 1). This ring did not give a sharp admission or cut-off, which was early recognized by the Brooks people, since their first packing was of the form shown in Fig. 2, giving a ring projection over the end of the valve.

The next modification was Fig. 3. This form of packing ring proved very successful with the low steam pressures then in use, being practically steam tight and probably much better in this respect than many modern types; but as pressures increased above 180 pounds, friction became excessive, since the whole

* American Locomotive Company, Schenectady, N. Y.

face of the valve was composed of expansive packing rings set out by steam pressure. It was superseded by the L-shaped ring, Fig. 5, which offers much less surface for the pressure to act upon, the T-ring composing the middle of the face being a solid non-expansive ring. This ring is practically standard throughout the country to-day.

When the L-shaped ring first came into use, it was feared that it would break because of its light section and cause damage by the pieces falling into the ports. To prevent this the form of ring shown in Fig. 4 was designed and is still used to a great extent. But strange to say, although breakage of valve packing rings is of too common occurrence, nothing more serious happens than is caused by the loss of the ring itself. Cases have been known of valves removed which were entirely innocent of packing rings, no portion of the ring being found in the cylinder or valve chest, and no other damage being done.

Early locomotive piston valve bodies, except those built at the Brooks Works, were made in one piece, the rings being "snapped" into place as in the ordinary solid head piston. But it has been found that, no matter how carefully these rings are turned to the bore of the bushing, this practice stretches them and causes a poor fit. This is the principal reason for the adoption of the built up valve (Fig. 6) which enables the rings to be slipped into place without distortion, and allows a deeper and heavier section to be used than would otherwise be possible. It will be noted that the Brooks Locomotive Works used this built up valve from the beginning (Fig. 2).

The best fitting packing rings are turned to the old piston ring rule—the rings are turned from 1/16" to 3/32" larger than the bore, according to the size of the valve, then from ⅛" to 3/16" cut out, the ring clamped together in a jig, and turned to nominal size. This gives a ring which will bear all around the bushing and wear equally.

Advantages and Disadvantages of Piston Valves.—We have thus brought the piston valve down to present day usage, which is well represented by Fig. 6. Some of its advantages are perfect balance, that is, when properly constructed, with just enough area of ring acted upon by pressure to make it properly steam tight, without unnecessary friction; a simpler, lighter, and cheaper cylinder casting; a wearing face separate from the cylinder casting which can be cheaply renewed; ports in cylinders readily made very straight and direct; and its adaptability to any design of valve gear, since it can be placed above the cylinder, between the frame rails, or in any other position with equal facility. Its general tightness to steam is conceded by engineers on both sides of the water to be about equal to a good slide valve.* Again, it practically does away with one set of metallic packing, as almost any form of hemp packing is sufficient to hold exhaust pressure, assuming the valve to be of the inside admission type.

On the other hand, it is accused of many shortcomings, most of which can be overcome, and some of which have already been eliminated in special designs in use to-day.

Many motive power men are of the opinion that an engine equipped with piston valves cannot develop the speed of a slide valve engine, both being otherwise of the same design. The fact that some of our very fastest trains are pulled by piston valve engines would seem to refute this argument; but as many of the older engines had valves entirely too small, these opinions may have been based on such poorly designed engines. Such an opinion might have been formed by comparison with outside admission piston valve engines. This is also unfair, as the outside admission piston valve has a proverbially poor exhaust. Inside admission has become the rule, and special care is at present taken to shape the steam chest covers to direct, and to offer the least possible resistance to the exhaust.*

As regards the size of piston valve required, we have many opinions; but it is an established fact that the circumference of the valve, less the space occupied by the bridges, must considerably exceed the length of the slide valve port for a similar bore of cylinder. This is accounted for by the resistance offered by the bridges, and by the fact that the portion of port diametrically opposite the cylinder cannot be so effective as that nearest it. The port should be so proportioned that the area around the outside of the bushing at any point is equal to the combined area of all the openings above this point.

The following table gives recommended diameters of valves for different bores, it being assumed that the sizes given are large enough for the longest stroke commonly used with this bore. The table also shows the net length of the port (with bridges deducted) for each diameter, and the corresponding length of slide valve port in common use.

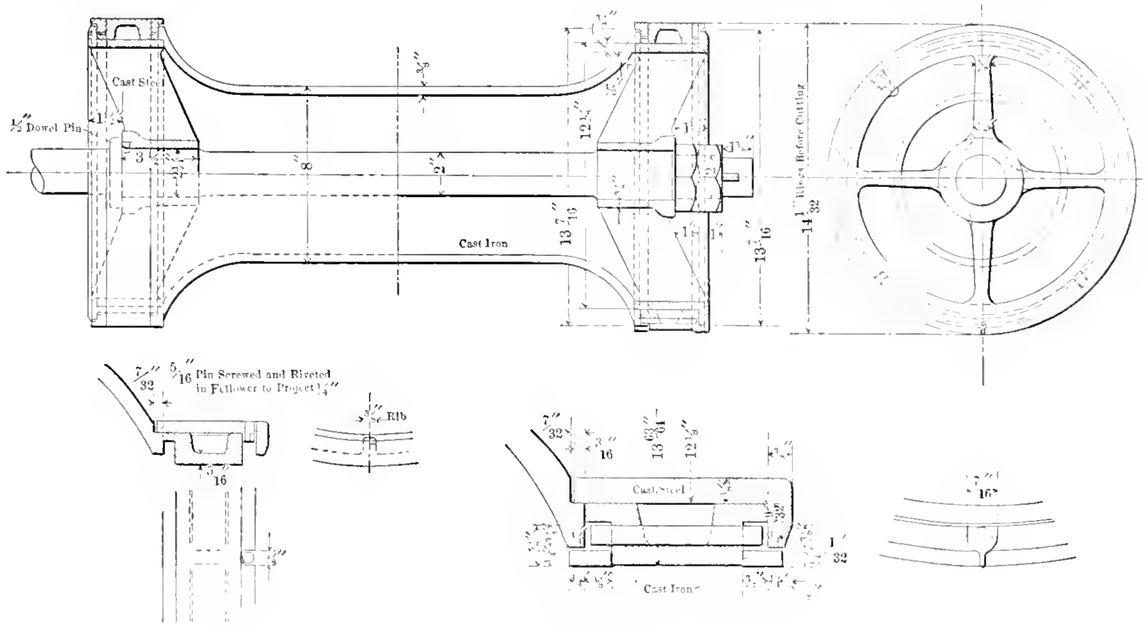

FIG. 6.

DIA. OF CYLINDER	DIA. OF PISTON VALVE	NET LENGTH OF PISTON VALVE PORT	LENGTH OF SLIDE VALVE PORT
17	10	25	16
18	11	26½	16
19	11	26½	18
20	12	30½	18
21	12	30½	18
22	12	30½	20
23	14	34	20

Another objection to the piston valve is the fancied increase of cylinder clearance. This, while it may be that clearance is

* AMERICAN ENGINEER AND RAILROAD JOURNAL, Sept., 1905, p. 318. Master Mechanics' Ass'n Proceedings, 1906.

* See description of L. S. & M. S. consolidation locomotive AMERICAN ENGINEER AND RAILROAD JOURNAL, Dec., 1903, p. 439.

larger in many cases than on a similar slide valve cylinder, is by no means necessary. It can usually be kept between 6 and 8 per cent., except on very short stroke engines, and this is low enough with ordinary valve gear, since the 2½ per cent. of the Allfree-Hubbell system is only made possible by the use of additional exhaust valves to relieve compression. The Allfree-Hubbell valve itself is really an inside admission piston valve, of rectangular shape.

In starting a train, with the gear in long cut off, inside admission valves have a tendency to jump at the moment exhaust takes place. This is very noticeable when there is excessive lost motion in the valve gear. It is caused by the action of the exhaust on the end of the valve, and is worse with a valve follower having a considerable overhang, with a long bevel as in Fig. 4 than for one like Fig. 6. Valves with a large diameter of body, forming a free communication between the opposite ends, to equalize the exhaust pressure and allow part of it to pass to the other exhaust port, rarely exhibit this fault.

The L-ring of the proportions generally used (Fig. 6) is open to another objection—the collapse of the exhaust ring just prior to release, due to the fact that in this position the lip of the ring has only exhaust pressure under it, while it has the pressure in the port on its face. This lip is usually ¼" wide, as on Fig. 6, and it has been found that with this proportion of ring, collapse takes place when the exhaust ring laps the port about ⅛". This suggests the remedy—reduce the lip to ⅛", thickening the body of the ring by that amount. Fig. 5, the standard valve of the Chicago, Burlington & Quincy Railroad, shows such a form (the Clark ring). However, the importance of this evil (the collapse of the exhaust ring) has been somewhat exaggerated. It cannot be detected on the indicator card, since the point of exhaust opening itself is rarely distinct except at very slow speeds, and the only effect is to round off this corner a little more. It cannot be detected in the sound of the exhaust even with valves having a long lipped ring. Its only effect on steam distribution is to cause a slightly earlier prerelease. The worst feature is in the increased wear on this ring and its joint faces, caused by this movement.

The greatest disadvantage under which the piston valve labors is its inability to relieve excess pressure in the cylinder port by lifting, after the manner of the slide valve. This renders some sort of cylinder head relief valve imperative. For this purpose the ordinary spring pop valve is generally used, and although many objections are raised to this device, it has not been proved that pop valves of ample size, properly designed and taken care of, will not eliminate cylinder head breakage, except in cases of deliberate attempt to use cylinders and pistons as hydraulic rams. Various types of by pass valves are also used with success, in which the pressure in the chest is made to serve in place of the spring, in a manner analogous to the slide valve. The Vogt by pass valve is typical of this class.* This valve is open to the criticism of considerably increasing the cylinder clearance, if the passages are made large enough to be effective.

Bushings.—Piston valve bushings ordinarily have from 7 to 9 bridges, one at the bottom being wider than the others, because of the joint in the packing rings at this point. These bridges, as has been said, obstruct the flow of steam to and from the cylinder by dividing it into small streams, the sharp edges of the ports having more or less of a retarding effect. Authorities differ greatly as to the importance of this evil, but all admit that the fewer bridges the better. If we could do away with packing rings, we could do away with bridges; this brings us to the consideration of the plug valve, which has been used on the Continent in locomotive work, and in an adjustable form by the Brooks Locomotive Works some years ago.

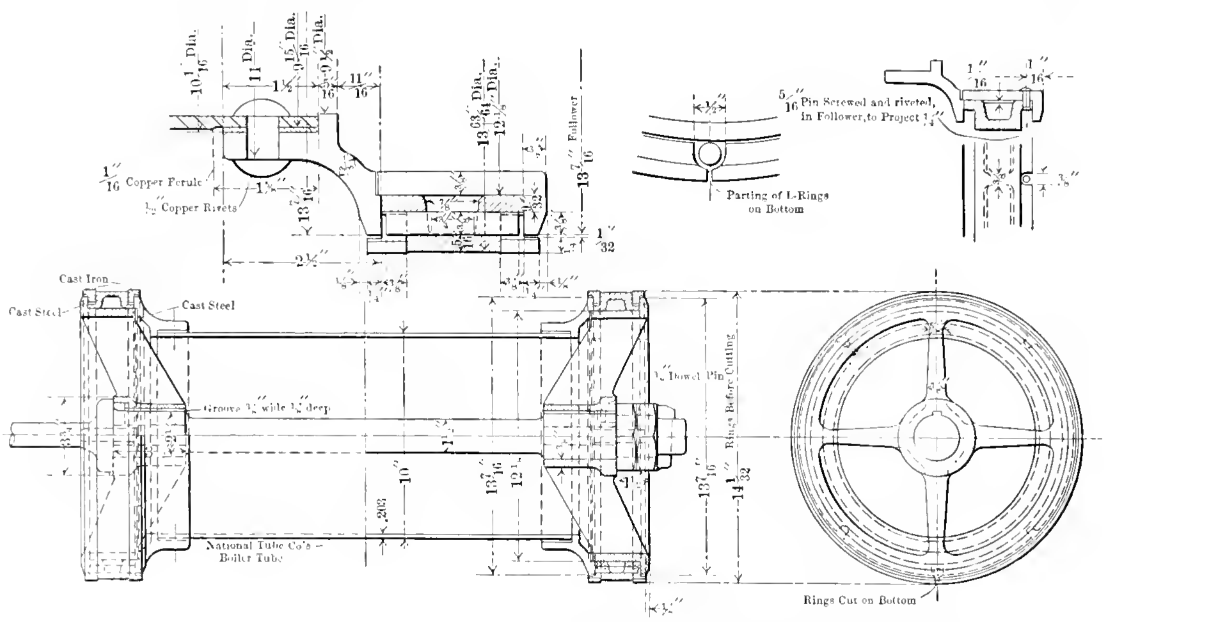

FIG. 7.—PISTON VALVE USED ON THE COLE BALANCED COMPOUND LOCOMOTIVE.

To use a solid, incompressable valve, of perfectly circular section and incapable of accommodating itself to the irregularities of the bushing, requires considerable modification in the bushing itself. In the first place it must be able to expand and contract independently of the cylinder casting; at the same time it must be held in true central position, with the steam edges of the ports always in the same relation to each other and to the cylinder itself. Moreover, at least two steam tight joints must be made on this bushing with the cylinder port walls. The valve must be of such section that it will not expand more quickly than the bushing when it suddenly comes in contact with the entering steam, and should cool at least as quickly when steam is shut off.

These conditions, together with a perfect fit between the valve and bushing, are said to have been met by the Schmidt valve, used in connection with the Schmidt superheater. This system employs for the purpose a double bushing, between the inner and outer shells of which steam has free access, joints with the port walls being made with copper gaskets. The valve is of small diameter, with a double exhaust feature. The system has been tried in this country without much success.

The form used by the Brooks Works was more successful, but has also gone out of use. In this type a single wide ring was used, with water grooves, which was cut in one place, and bolted together by means of lugs on the inside, liners between the lugs providing for accurate adjustment to the size of bushing.

The nearest thing to the plug valve in successful service is the American "Semi-Plug" valve.† It is believed that this valve could be successfully used in a bushing without bridges; and

* See AMERICAN ENGINEER AND RAILROAD JOURNAL, Oct., 1904, p. 384.
† See AMERICAN ENGINEER AND RAILROAD JOURNAL, Sept., 1906, p. 361.

aside from this fact the design is undoubtedly most successful from a point of view of maintenance. The American "Semi-Plug" valve is the only working illustration in American practice of the collapsable valve.

As a type of the modern valve, showing the lightest possible construction, combined with great strength, attention is called to Fig. 7, which is the valve used both on the high- and low-pressure cylinders of the Cole balanced compound. In this the body or spool consists of seamless steel tubing, with light cast steel ends riveted on.

Fig. 8 shows a double-ported valve for the low-pressure cylinder of a Mellin cross-compound, for passenger service. This gives the large port-opening necessary for high speed work, with very large cylinders. The prototype of this valve has long been in successful service in the engines of the battleship Texas.

Lubrication.—That the piston valve is much easier to lubricate than the slide valve is undeniable, since a cut bushing is almost unknown, while the scored valve seat is always with us. It is also true that while the piston valve is used with perfect success, with highly superheated steam, it has been found almost impossible to properly lubricate a slide valve under these conditions.

There are two methods of applying oil to the inside admission piston valve, each of which has its advocates; the first being its introduction to the center of the chest, or steam passage in the saddle, while the second involves the use of branch pipes which deliver the oil at the top of the valve itself, through a hole in each bushing. This is much more certain and economical, provided the oil holes are not spaced so widely apart that the steam ring passes over them, thereby making it dependent upon the exhaust ring to keep the oil out of the exhaust passage. The exhaust ring, as has been pointed out, is more or less unreliable, and as a result the oil is blown past it and lost both to the valve and the cylinder. The oil studs should be so spaced, when this method is used, that the valve will just wipe off the drop at the shortest stroke.

The piston valve is daily coming into more general use, as its errors are corrected and prejudice overcome. On some of our trunk lines it has practically superseded the slide valve, and it seems idle to longer deny it at least equal rank with its older competitor.

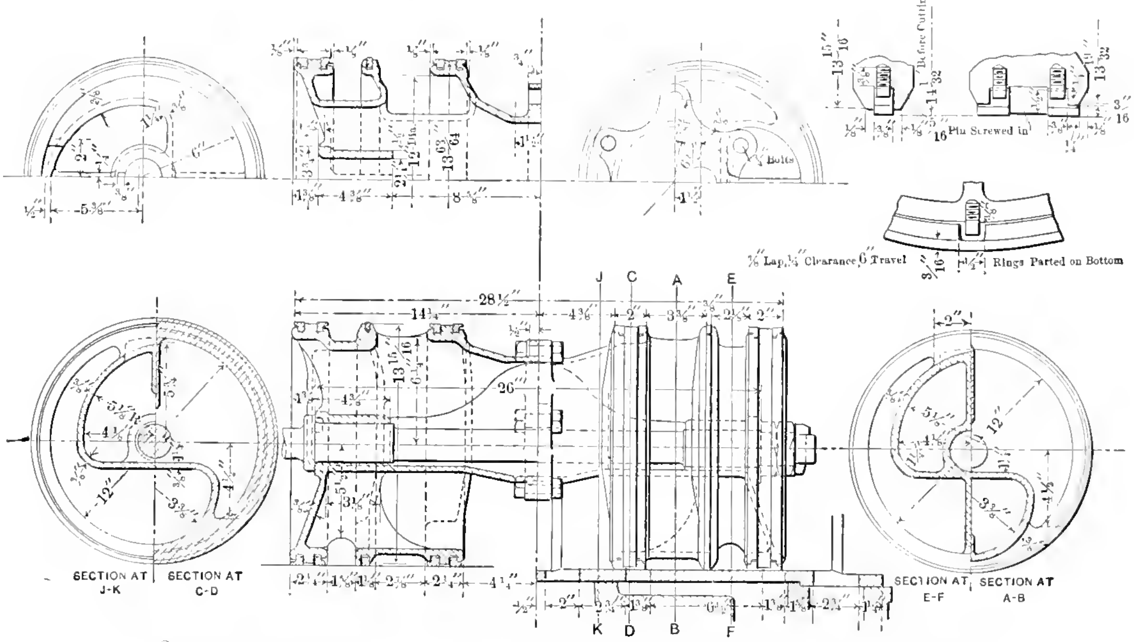

FIG. 8.—DOUBLE-PORTED VALVE FOR LOW-PRESSURE CYLINDER OF A MELLIN CROSS-COMPOUND.

MOTOR CAR DESIGN.—A motor car operated in connection with steam train service will, at times, be subjected to severe shocks, and it has been my idea to design a car of steel that would be susceptible to any sort of a shock without danger of collapsing or telescoping. With the ocean liners of ponderous weight a collision will result in a hole being punched in the side of the vessel, but, as a rule, the other parts of the frame will not be damaged; many valuable ideas may be drawn from the experience obtained in modern shipbuilding. Instead of having an underframing of excessively heavy sills with a light cracker-box framing above, we have endeavored to make the whole car body a unit structure, heavy parts of which brace its adjacent members, and in case of a wreck every bit of steel in the car would be utilized in offering resistance. Thus, our underframing comprises but one moderately heavy center sill; the side sill is a light weight continuous channel extending around the body of the car. From this outer channel bar we have continuous steel ribs running up the side through the roof and down the other side of the car; these are braced to each other by suitable cross-braces. The sides of the car form a truss; the plate of the car being the top chord and the sill being the bottom chord. This framing is well tied together at all points, and is further reinforced and strengthened by the sheet steel covering. The ends of the car are enormously strengthened by the round shape at the rear and the pointed lines in front. In a collision this car could be punctured or bent, but it could not be telescoped.—*Mr. W. R. McKeen, Jr., before the New York Railway Club.*

ELECTRIC LIGHTING OF TRAINS, whether the current is generated by a steam engine and dynamo in the baggage car, or whether the generators are driven from the axles of the cars, results in an increased coal consumption by the locomotive. The Northwestern Limited trains between Chicago and St. Paul are lighted by the former method, the current in use during the evening representing about fifteen kilowatts, or twenty horse-power. If each car is lighted with 600 candle-power, there will be about 2,400 watts required, or, say three horse-power per car, and this will represent in round numbers about fifteen pounds of coal per car per hour.—*William Penn Evans before the Pacific Coast Railway Club.*

MR. RUBEN WELLS, after twenty years' service as superintendent and manager of the Rogers Locomotive Works of the American Locomotive Company, has resigned. Mr. Wells started his railway service as an apprentice in the Philadelphia & Reading shops at Reading and in 1852 went to Shelbyville, Ind., as master mechanic of several roads, which were afterwards consolidated as the Jeffersonville, Madison & Indiana Railway, with which company he remained for twenty-five years, during five years of which he was a trustee of Purdue University. In 1878 he went to the Louisville & Nashville Railway as superintendent of machinery, afterwards being promoted to the position of general manager, and in 1885 was made assistant to the president. In 1887 he left this road to become superintendent of the Rogers Locomotive Works, of which he was made manager in 1900.

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What is the matter with the compound? What is the matter with the superheater? What is the matter with a feed-water heater? What is the matter with a variable exhaust nozzle? Well! what is the matter with them? One authority states that they are not "fool proof," *i. e.*, they will not operate successfully without attention, and hence are not suitable for American locomotives. There is no doubt but what any or all of these things will increase the capacity of our locomotives and our firemen, but we can't take advantage of the opportunity because we can't take care of them. Is this true?

The practice of reading the committee reports and individual papers in full at the Master Mechanics' and Master Car Builders' conventions should be discontinued. The men who are in a position to intelligently discuss these papers before the convention are those who have studied the paper beforehand. The chairman of the committee should in a clear manner present a very brief extract of the report in introducing it. Much valuable time is lost and the members present are often wearied by the useless reading of a long report or even of any considerable portion of it.

The piston valve for locomotives has reached a stage where it can safely be called a success. In arriving at this point it has had to pass through many alterations, each small in itself and in no way affecting the basic principle, but which, when taken together, amount to practically a new device as compared to the first attempts. Its present success is built on the firm foundation of the elimination of the weak features as they appeared and the proper understanding of the lessons taught by practice. The account of this development, as given by Mr. Stafford in an article on page 174 of this issue, will no doubt be of much interest and value to our readers.

The practice of changing driving wheel tires in the roundhouse when the locomotive is not ready to go into the back shop for heavy repairs is followed with very satisfactory results on a number of roads. The ordinary practice is to shrink the tires on a pair of wheel centers and turn them in a driving wheel lathe. The labor cost of putting a pair of tires on the centers and removing them after they have been turned would amount to at least 40 cents and the cost of the gasoline for this purpose would come to about $1.50. The actual labor cost of turning the two tires will, of course, vary in different shops, but in one shop it costs $1.50 a pair. It was found after careful investigation that the tires could be turned on a boring mill at a cost of 80 cents apiece as against $3.40 per pair or $1.70 apiece, as above. The boring mill was not of very recent design and was not equipped with a universal chuck. Two tools were used. On a modern heavy-duty mill equipped with a universal chuck this work could probably be handled to still better advantage. The space occupied by such a mill would not be greater than for a driving wheel lathe and the first cost of the boring mill would probably be less.

We are informed that an effort will be made at the Atlantic City conventions to prevent the sessions from being disturbed by noise from the exhibits or by the moving of material in the vicinity of the meeting hall. If this is done it will be greatly appreciated by the members who attend the convention. The way in which previous conventions have been disturbed is shameful. It is rather strange that some of the supply men who are trying so hard, otherwise, to make a good impression should so far forget themselves as to carelessly disturb the deliberations and cause a great annoyance to members. If the individual members of the associations will take the trouble to personally show their displeasure at occurrences of this kind there is no question but that the exhibitors will realize that their cause can be hurt a great deal more by such conduct than by all of their efforts to produce a good impression. If the exhibitors

will not honestly try to remedy this trouble it is apparently up to the railroad men to force them to do so. The work of these associations is too important to have it hampered or interfered with on the way and it it earnestly hoped that some decisive step will be taken to stop it.

A number of railroads, which up to this time have used wooden equipment exclusively, are seriously considering the introduction of steel cars. The purpose of the rather extensive article on the maintenance and repair of steel freight cars, in this issue, is to show, as clearly as possible, the advantages of steel cars from the standpoint of maintenance and repairs and the ease with which they may be repaired with almost no special facilities. Through the courtesy of Mr. J. E. Muhlfeld, general superintendent of motive power of the Baltimore & Ohio Railroad, we were enabled to make a careful and extended study of this question on that road, and trust that the results may be of value to those who are considering the introduction of such equipment or are interested in its design or maintenance. Those roads which are introducing steel equipment should benefit by the experience of those which have used steel cars for a considerable time. The experience of such roads apparently indicates that it is poor policy to attempt to reduce the dead weight of the car to too great an extent, as the additional first cost and the cost of carrying the increased weight is more than offset by the increase in repair costs.

The circular of inquiry sent out by the Committee on Subjects of the Master Car Builders' Association should meet with the hearty approval of every member of that organization, and this approval should be demonstrated in a practical way by assisting the committee in its effort to place the work of the association on a higher plane. The substance of the circular is as follows:

"The Committee on Subjects believes that the lists presented heretofore have often included a number of subjects which related to small, unimportant details and difficulties experienced only by a limited number of the members. Subjects for investigation by the committee should relate to matters of large importance and should be such as will require the committee to make extensive investigations on their own account and not to simply ask questions and print answers. The members are requested to give more careful attention to the replies to this circular than have usually been given, for the fact is often lost sight of that the program for the convention, which is largely made up of recommended subjects, occupies a large part of the attention of the convention, which is held at a great expense, and which should result in as much useful work as possible. Subjects as announced in the program have been too brief and they should be accompanied by instructions to the committee telling what is expected of them and always, if possible, leading to some positive conclusion or recommendation as a standard or recommended practice of the association."

* * * * * * * *

In this connection it is suggested that the Association should give more attention to steel freight and passenger car equipment. All-steel freight cars have now been in service in large numbers for eight or nine years and yet the Association has given them practically no attention, other than the drawing up of a schedule of prices for repairs. Meanwhile the number of these cars has been steadily increasing until, at the present time, there are several roads upon which as much as from 20 to 50 per cent. of the freight equipment is of all-steel construction.

Conditions at present are such that it is almost impossible, in many districts, to secure proper timber for car building, regardless of the price, and on many roads timber is being used which six or seven years ago, or even less, would have been rejected. For certain classes of service, the all-steel equipment is coming into general use and it would seem advisable for the Association to place as much information, as possible, on record concerning these cars, to assist the members at large and especially those who will have to go into the matter of steel equipment in the near future. That such information will be timely is indicated by the fact that a number of Western roads have recently sent their representatives to Eastern roads who have steel car equipment, to investigate the utility of these cars and the methods of repairing and maintaining them.

Although a large number of steel cars have been in continuous operation for the past seven or eight years the opinion still seems to prevail, in some quarters, that the side and floor sheets of these cars will have a useful life of only about ten years or less. As a matter of fact cars which have been running under adverse conditions this length of time are still in good condition, and will undoubtedly give good service for several years more. The Association could profitably investigate the question of the design and maintenance of these cars with a view to gaining the best results both as to increased life and service requirements.

It is a great many years since a locomotive fitted with a feed-water pump has been illustrated in this journal, but such a design has recently appeared on one of the prominent railway lines in England, and is shown in this issue. This pump naturally differs as much from the pump in use 15 or 20 years ago as the locomotive itself differs from its predecessor at that time. In this case it is entirely independent of the running gear of the locomotive and consists of a small upright double-acting duplex pump fastened to one of the frame braces, in such a location that it is fed by gravity from the tender. Its operation is controlled by the control of its steam pressure in the cab and can be as finely adjusted to the running conditions of the locomotive as can an injector. It discharges through a feed-water heater in the front end and a check valve on the front tube sheet.

The use of a pump was necessitated in this case by the desire to use hotter feed water than can be successfully handled by an injector. The exhaust steam from the pump is condensed in the feed-water tank, which water is also further heated by a supplementary connection from the exhaust passage in the cylinders. In this way the feed water, if desired, can be heated up to 212 degs. before reaching the pump and afterwards by a proper design of heater or economizer in the front end can be put into the boiler at nearly the temperature of the water in the boiler, almost all of which heat is obtained from a supply that is ordinarily entirely wasted, *i. e.*, exhaust steam and front end gases.

From experiments which have been made of the temperature at different points of the locomotive boiler it is easy to believe that the injection of feed water at practically the temperature of the water already in the boiler will tend toward a material reduction in boiler repairs. Furthermore, the heat that enters with the feed water naturally does not have to be supplied from the heating surface of the boiler, thus resulting in a material saving in fuel.

It is interesting to examine, for a special case, what this saving might actually be. The total heat in one pound of steam at 200 lbs. pressure is about 1,200 B. T. U. The temperature of the water in the boiler, 200 lbs. gauge pressure, is about 387 degs. and assuming a temperature of feed water at 60 degs., if this feed water is heated to 300 degs. before being put into the boiler, we have added 243 B. T. U. or over 20 per cent. of the total amount of heat required in changing the feed water at 60 degs. into steam at 200 lbs. pressure, all of which heat, with the exception of that rejected by the pump, has been obtained from that ordinarily wasted. With the injector, on the other hand, the heat that is put into the feed water is all taken from the live steam in the boiler and hence there is no gain from waste sources, nor is the feed delivered at anywhere near the temperature of the water in the boiler.

In considering this question, it should not be forgotten that a feed-water heater which would give the temperature assumed above will also act as a feed-water purifier and much of the scale-forming impurities will be deposited on the tubes of the heater. This would be hard on the heater, but a good thing for the boiler.

EQUALIZERS ON PASSENGER TRUCKS.

To the Editor:

Referring to the communication on page 102 of the March issue of your journal on "Equalizers on Passenger Car Trucks." If we remove the equalizers from our passenger car trucks and put blocks between boxes and frame, we would practically have a caboose truck or a freight car truck with elliptic springs, and anyone who ever rode in a caboose knows the bad riding qualities of such a truck. On the other hand, everyone knows the smooth riding qualities of a six-wheel truck, and this is brought about by the greater equalizing effect as the same number of springs are generally used in six-wheel trucks as are used in four-wheel trucks. If we were able to remove the equalizers

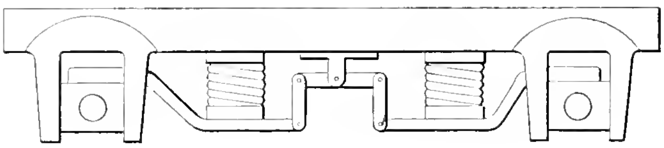


Fig.1

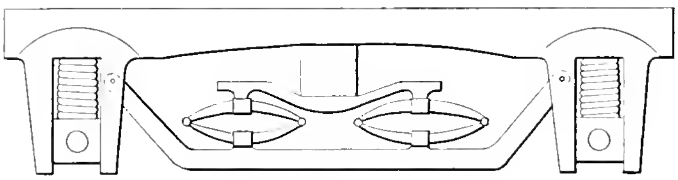


Fig.2

from passenger car trucks and get the same results, we should for the same reason be able to remove the equalizers from our locomotives which every locomotive expert knows is impossible, otherwise they would have been removed long ago, as they are a great deal more expensive both as to first cost and maintenance, than passenger truck equalizers.

I have in mind, at present, some Mogul engines which were under my jurisdiction, that rode so rough that some engineers refused to go out on them, and they were continually breaking springs and spring rigging. These engines were not equalized between the drivers, only from front driver to truck, and after a careful investigation we placed equalizers between all wheels, making a continuously equalized spring rigging. Following this change they were the best rigging engines on the road. I do not know why the same should not be true on passenger trucks.

I inclose two sketches of patented devices in which the intention was to get an equalizing effect on a four-wheel truck equal to the six-wheel truck, I do not remember the patentee of the arrangement in Fig. 1, but Fig. 2 is the Standard Car Truck Company's truck.

In my opinion, on account of the roughness of some of our roads, what we want is more equalization instead of reducing it. The cause of easy riding of European cars is mainly because of the perfect condition of the roadbed and its perfect maintenance, and the trucks are also much lighter on account of the much lighter weight and smaller size of cars.

Yours truly,

Indianapolis, Ind. B. D. Lockwood.

STEEL BOX CARS.

To the Editor:

I would like to ask a few questions about the all-steel box cars of the Union Pacific type, as built at the Omaha shops, and illustrated in your April issue.

1. What is going to happen when the steel side and floor plates become damp from either the material carried or from frost? It must be remembered that no sunlight can dry out the inside of a box car as it can a steel flat, or gondola car.

2. What will be the result when these side or bottom plates do become rusted and pieces of rust drop off into a cargo of grain?

3. In view of the above possibilities, should not a light wooden flooring be laid over the steel floor plates and light wooden posts be bolted to the T-iron posts and a light wooden inside lining be nailed to them? If wooden grain doors were provided this would keep any of the material being carried from touching the steel in any place. All of the above wood could be of the fireproof variety if thought necessary.

I ask the above questions in view of the fact that the standard box car of to-day is available for lading of practically all kinds and I am afraid that a steel box car of this design would not fulfil the same conditions and would be available for only certain limited classes of freight, which as a general proposition would be a step of retrogression instead of progress.

Another feature of these cars that should receive attention, which it apparently has not received in the design shown, is the matter of ventilation. Such a car as has been built by the Union Pacific when closed and sealed would in hot weather simply become a bake oven with a resulting damage to certain other classes of freight which would not be subjected to the objections mentioned above. There is also the matter of sweating following the cooling down, which was mentioned in your editorial on this subject. Ventilators could easily be applied to these cars and would largely eliminate this trouble.

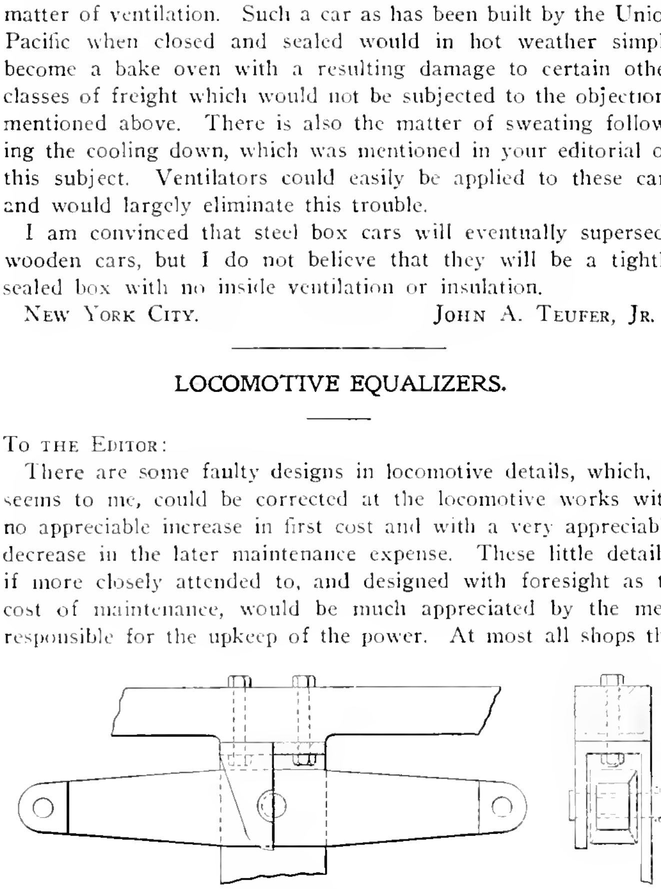
I am convinced that steel box cars will eventually supersede wooden cars, but I do not believe that they will be a tightly sealed box with no inside ventilation or insulation.

New York City. John A. Teufer, Jr.

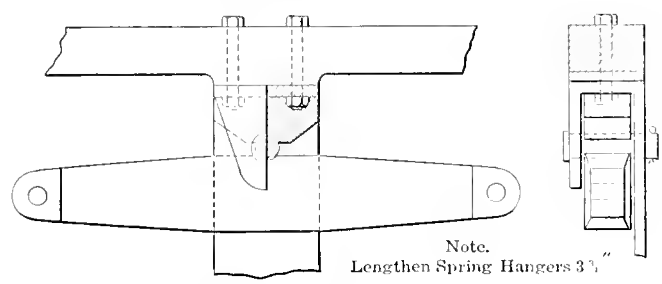
LOCOMOTIVE EQUALIZERS.

To the Editor:

There are some faulty designs in locomotive details, which, it seems to me, could be corrected at the locomotive works with no appreciable increase in first cost and with a very appreciable decrease in the later maintenance expense. These little details, if more closely attended to, and designed with foresight as to cost of maintenance, would be much appreciated by the men responsible for the upkeep of the power. At most all shops the



Present Arrangement



Proposed Arrangement

foremen are constantly making improvements or alterations to better design, and yet new engines are continually being built with the same faulty construction.

One such instance has lately come to my notice and I am enclosing a blue print showing a proposed change in locomotive spring rigging which will illustrate my point. The change as suggested will do away with boring and bushing the pin hole in the equalizer and bracket, which on account of small bearing surface in the bracket soon wears large in the present design, permitting the equalizer to ride on bracket nuts and bolt heads, resulting in loose bolts and poor equalization of weight on the springs as well as a large expense in refitting at frequent intervals.

G. D. Siemantel.

THE CENTRAL REPAIR AND MANUFACTURING SHOP

Its Advantages and Disadvantages.

By C. J. Morrison.*

(Editor's Note.—This article is based on recent observation and study of a large number of railroad shops in various parts of this country.)

The majority of the railroads have come to the conclusion that there is economy in having one large central shop which shall do the heaviest repair work and also serve as a manufacturing plant for the system. With this general conclusion in mind much work has been undertaken without careful study of various important phases of the problem.

Consider first the repair problem. Probably the item of greatest importance is the length of time an engine is out of service. To the time actually spent in the shop must be added the time waiting for repairs, and the time in transit to and from the shop. If this total time out of service is less than the total time required at the local shop, it will be an economy in point of time to send the engine to the central shop. A careful study of the records of a large number of shops on different roads shows that the large shops are able to handle an engine in from 35 to 45 per cent. less time than the smaller shops on the same road, considering time in the shop only. However, an engine often stands on the hospital track waiting for repairs a longer time than it spends in the shop, thus placing the large shop on a par with the smaller shops as regards the time element.

As a rule an engine does very little waiting at one of the small shops, but is taken out of service and placed in the shop on the same day. This difference is accounted for in several ways. First, the small shop is usually in charge of a master mechanic, who also has charge of the division upon which the shop is located, while the large shop is entirely divorced from the road and is in charge of a shop superintendent. As the master mechanic has control of the engine all the time, he is able to keep it in service, by the aid of careful roundhouse work, until he can handle it to advantage in the shop. On the other hand, the shop superintendent has no voice in the matter, and an engine may be sent to him six weeks before he can possibly find room for it in the shop. Engines are also often sent without any notice being given that they are to be shipped and without any report being made as to the nature of the repairs required. This frequently results in an engine standing in the shop for days waiting for some part, such as a cylinder or a firebox, while the material would have been ready had a proper report preceded the engine. The organization on many roads is deficient in this respect. In order that the central shop may effect an economy in the time required for repairs, the hearty support of the outside points must be given.

A scheme which is giving satisfactory results, is to assign an arbitrary mileage to each engine when it leaves the shop. As soon as a master mechanic receives an engine from the shop he assigns a mileage, based on the condition of the engine, the service expected and the division upon which it is to be operated, which it must make before it is again shopped. Thus an engine in a level country with good water may be assigned 90,000 miles while the same engine if operating in a bad water district, with heavy grades and curves, might be assigned only 60,000 miles. At the first of the month each master mechanic makes a report showing the total mileage made by each engine and the mileage yet to be made. If the mileage to be made is decreasing faster than the actual mileage is made, an explanation is required.

For example, assume that engine 1987, turned out of the shop February 1st, is assigned 90,000 miles, makes 3,000 miles during February and is shown March 1st as still able to make 80,000 miles, an explanation must be made. On the other hand, after an engine has been out several months and the mileage required is getting low, light repairs may be given to it, and the next report show an increase in the mileage required. In this case an explanation is also given. By this method a close tab is kept on the condition of the power and the approximate date when each individual engine is to be shopped is known. Space in the shop is reserved accordingly and material is gotten ready in advance. Wrecks alone interfere with this scheme, but as a certain allowance is made for these, no serious disadvantage is caused.

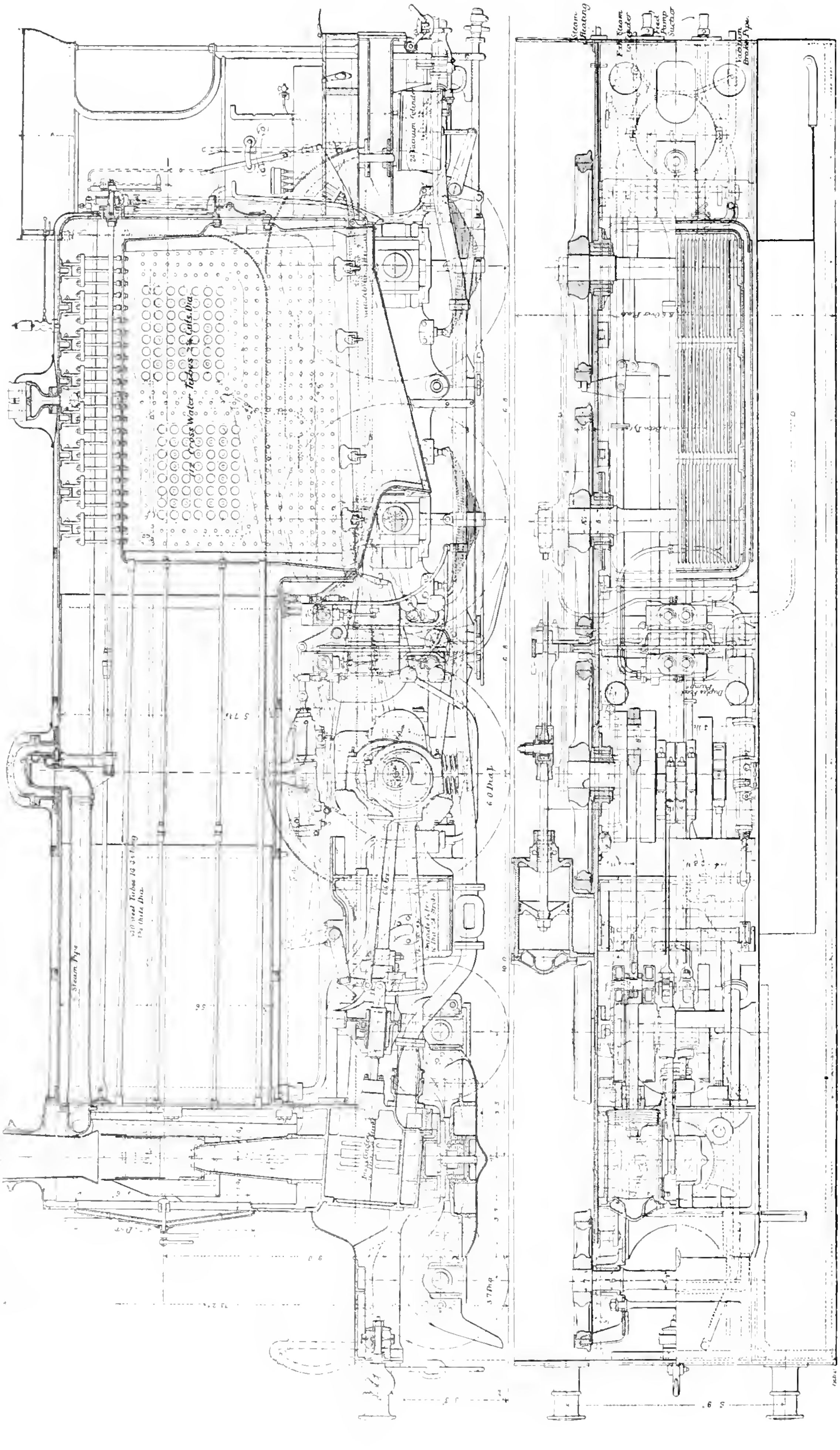
In the matter of cost of repairs the large shop is found to be able to do the same work at from 20 to 35 per cent. less, including surcharges, than the smaller shops. This is largely due to the organization possible in the large shop. Here men become specialists and do their own particular work in a time impossible to the all-around man in the smaller shops. However, the large shop will not be able to effect this saving unless standard parts and specifications are adopted and strictly adhered to. Each shop must be required to finish material to standard and to erect and maintain the engines to standard specifications. It is a very common practice on some roads for an engineer, road foreman or master mechanic to change engines from the standard. Not only this, but the different shops on a system often finish material and erect engines according to their own ideas. This adds greatly to the expense of maintenance as an engine must be made standard again when it changes divisions or when it goes to the general shop. In some cases the added expense is as much as threefold. Assume, for instance, that a new engine just received from the builder, standard in every detail, is altered by some master mechanic, makes its mileage and is sent to the general shop. As the shop has no authority for the changes, the engine is erected to standard prints, and returns to the division from whence it came. Here it is again altered. If engines are changed from standard so that each engine becomes a problem in itself, the advantage of the specialists is largely eliminated.

From the manufacturing standpoint the importance of standards becomes even more evident. The large shop is placed practically on a small shop basis if articles must be made to different specifications for each point on the road. Economy is obtained only when each article is made in large quantities. Not only is this true concerning the actual manufacture, but the stock required becomes smaller as the number of different patterns decrease. On some roads it is the practice for each division on a system to have its own standards and its own methods. This means that the central shop must manufacture separately for each division and also that finished material cannot be transferred from one division to another, but that each must keep its individual stock. It also means that unless great care is taken, articles manufactured for one division will be shipped to another where they will be practically useless. To prevent such mistakes the cost of supervision is increased.

The practice of manufacturing at one central shop and shipping material to the smaller points ready to apply has, in many instances, raised the cost of repairs. This increased cost was brought about by the application of new material where the old parts should have been repaired. Instances are recorded where entire new driving boxes have been applied instead of new brasses being pressed into the old boxes. New shoes and wedges are put up to avoid lining the old ones, and, in one extreme case, a new four guide crosshead was applied to avoid thirty minutes' lathe work on the old one. Examples of these practices are not confined to any one system, but have been observed on large roads all over the country. Such work can be eliminated by careful supervision and by impressing on the foreman the cost of each article.

It is obvious that the central repair and manufacturing plant will be an economy only when standards for parts and for erecting are adopted and strictly adhered to, when engines are required to make a specific mileage, when careful inspection reports precede an engine to the shop, when the shop is notified in advance when such engines will be shopped, and when the waste of material is eliminated. The last clause should be understood to include stopping the practice of robbing an engine before it is sent to the central shop.

* General Erecting Foreman, Topeka Shops, Atchison, Topeka & Santa Fe Railway.



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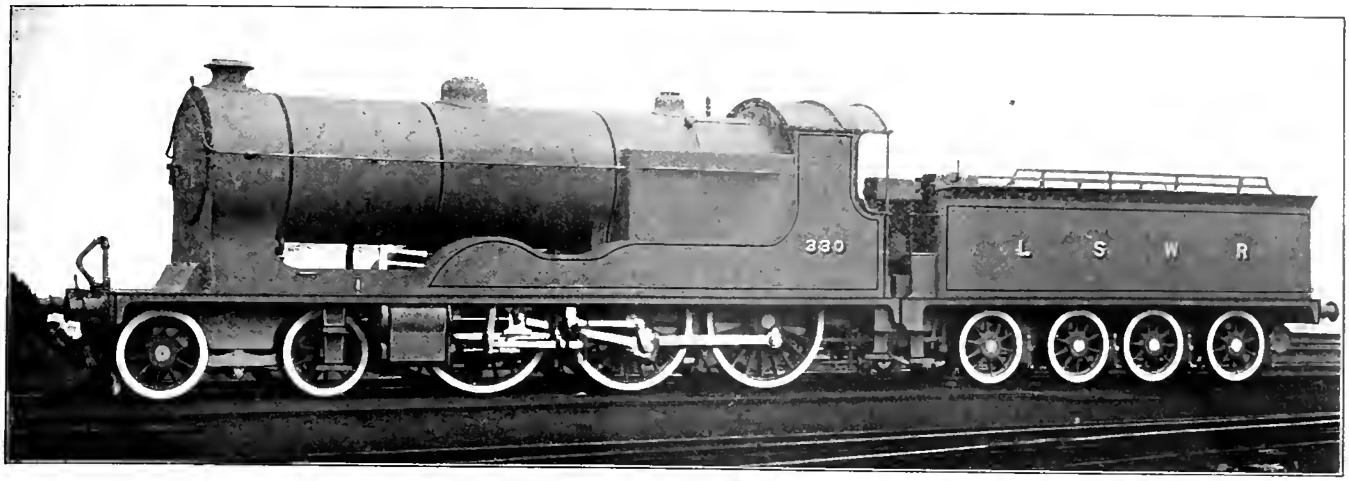
SECTIONAL ELEVATION AND PLAN OF FOUR-CYLINDER SIMPLE LOCOMOTIVE—LONDON AND SOUTHWESTERN RAILWAY.



FOUR-CYLINDER SIMPLE LOCOMOTIVE—LONDON AND SOUTHWESTERN RAILWAY.

FOUR-CYLINDER SIMPLE TEN WHEEL LOCOMOTIVE.

LONDON AND SOUTHWESTERN RAILWAY.

BY CHAS. S. LAKE, A. M. I. Mech. E.

The London and Southwestern Railway has had in service during the past 18 months, a class of four cylinder simple locomotives of the ten-wheel type built from designs prepared by Mr. D. Drummond, locomotive superintendent, which, in view of the very general interest being taken in this type of powerful, high speed locomotives, offer many points of interest.

The four single-expansion cylinders are arranged as in the de-Glehn compounds, viz.: with one pair inside the frames, below the smokebox, driving the crank-axle of the leading pair of drivers, and the outside cylinders set back of the truck and connecting to the middle drivers. The cylinders are all 16 x 24 in. and two separate sets of valve gears are provided, the inner one being of the Stephenson type and the outer of the Walschaert. The driving wheels are 72 in. diameter and the total weight in working order is 103,520 pounds. The tractive effort figured as two simple engines is 25,300 pounds.

These locomotives have been designed primarily for dealing with the heavy and fast passenger trains comprised in the principal express summer services of the London & South-Western Railway. They are employed on the west of Salisbury division and chiefly between that place and Exeter, where heavy and continuous grades are met with. Some of these have an inclination of 1 in 70, and the one which reaches its summit shortly after clearing Honiton tunnel is 10 miles long; the highest point being 470 feet above sea level.

The principal "West of England" expresses of the London & South-Western Railway consist during the summer months of seven 30-ton corridor cars and one 40-ton dining car. The trains are vestibuled throughout and weigh loaded about 280 tons, exclusive of engine and tender. The new 4-6-0 type 4-cylinder locomotives were used for the first time on this traffic during the summer of 1906. They worked the trains regularly between Salisbury and Exeter and *vice versa,* a distance of 88 miles; the average speed being 52 miles per hour. The coal consumption during the heaviest period of service, viz., July, August and September, averaged 40 lbs. per mile, the lowest rate being 35 lbs. and the highest 47.3 lbs., and evaporation of water was at the rate of 10 lbs. per pound of coal burned.

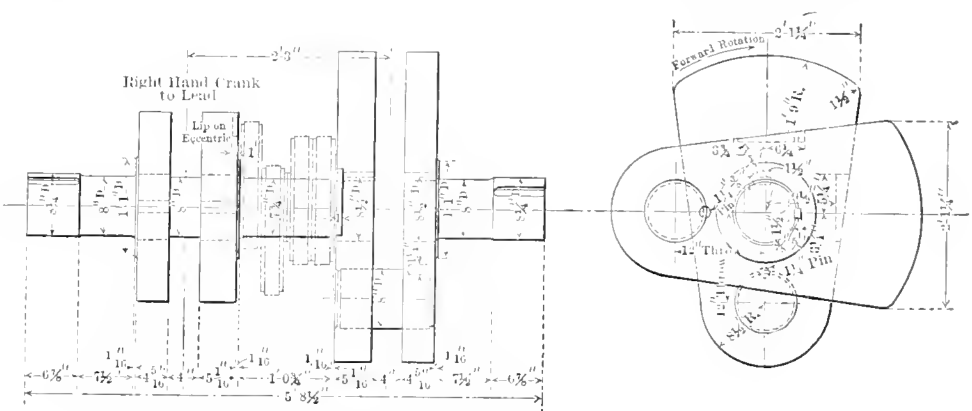
During the winter of 1906-7 the engines have been employed hauling special freight trains running on a fast schedule between Salisbury and Exmouth Junction (Exeter). These trains make one intermediate stop of 30 minutes' duration at Yeovil Junction, and they are allowed 4 hours 6 minutes gross, or 3 hours 36 minutes net running time in which to perform the journey. The trains are comprised of 45 to 50 loaded cars of miscellaneous types, the total weight of train varying from 600 to 700 tons behind the tender.

The cranks on the front axle are, as will be seen in the illustrations, of the balanced type having large projections opposite the crank pins; there are no weights cast with or attached to the wheel centers, these being unnecessary, as all the revolving weights are balanced in the axle and in the planes in which the larger part of the disturbances are created. The stresses are kept more nearly in line when axles are constructed in this way and a much easier running engine results.

The crank-axle is of mild steel of the built up design, the webs being in one piece with the balance weights. The throw of the cranks is 12 in., but that of the coupling rods is only 10 in. The crank pins and coupling-rod pins for the outside cylinders are in one piece, but are turned to different diameters with 2 in. of eccentricity.

The outside cylinders are each connected to the frame by a box casting or distance piece, which locates the cylinder center properly in line with the crank-pin of the middle drivers. This casting is made considerably shorter than the cylinder itself, so that it fits closely in between the rear truck wheel and front driver, whereas the cylinder itself overlaps the latter. Incidentally this permits of the total wheel base being shortened, inasmuch as the leading drivers are brought closer up to the truck than could be done if the outside cylinders were bolted to the frames for their entire length. The inside cylinders are inclined at 1 in 14, their axes intersecting the center of the crank-axle, which is driven through connecting rods 6 ft. 6 in. long.

The four cylinders are each 16 in. diameter, giving a total piston area of 804 square inches, with a piston stroke of 24



CRANK AXLE—FOUR-CYLINDER SIMPLE LOCOMOTIVE.

inches; thus we find they are in the aggregate equal in volume to two cylinders of 22 in. diameter by 26 in. stroke taking steam direct from the boiler. It would be a matter almost of impracticability to fit two such large cylinders inside the frames and their arrangement outside the frames could only be accomplished at some inconvenience to come within the width allowed by the British gauge limitations.

The exhaust ports are 3 in. wide and steam ports 1¼ in. The port faces of the inside cylinders are at the sides so that the two slide-valves work back to back between the cylinders, but the outside slide-valves work underneath the cylinders.

Reversing the valve-motions is done by means of a combined arrangement actuating all four gears simultaneously and operated by a steam and hydraulic device, the cylinders of which may be seen in the drawings located just inside the frame on each side of the engine, above the crank-axle. The steam supply to all four cylinders is controlled by one throttle valve and all exhaust through the same exhaust pipe.

An engine having the cylinder proportions of this one needs ample boiler capacity to ensure success, and in this respect the designer has gone practically as far as is possible within the loading gauge. The boiler barrel has an internal diameter of 5 ft. 6 in. at the front and is 14 ft. 2 in. long between tube plates. It contains 340 steel tubes 14 ft. 4½ in. long by 1¾ in. outside diameter, and 13 S. W. G. thickness.

These tubes provide 2,210 sq. ft. of heating surface, all of which may be regarded as effective as their length is moderate and the special spark arresting and fuel economizing device located in the smokebox tends to retard the passage of the gases through the tubes and creates an equal draught through all of them. Much valuable heat which would otherwise pass away into the atmosphere unabsorbed is thus retained in the boiler in contact with the surfaces prepared to receive it. The boiler barrel tubes are supplemented by two groups of water tubes across the firebox. These have an outside diameter of 2¾ in. and, in the aggregate, number 112, giving an additional heating surface of 357 sq. ft., which, added to the 160 sq. ft. of the firebox plates, and the 2,210 sq. ft. of the ordinary fire tubes, brings the total heating surface of the engine up to 2,727 sq. ft.—an unusually large amount for a British locomotive. The grate area is in proportion, viz., 31.5 sq. ft., and the working steam pressure is 175 lbs. per sq. in.

The cross water tubes in the firebox are inclined from side to side, one group sloping from left to right and the other group in the opposite direction. This ensures thorough circulation of the water and conduces to extreme rapidity in steam raising. The rectangular projection seen on the side of the firebox in the photograph is a covering plate for the hinged doors which give access to the ends of the water tubes on each side. Apertures are formed in the outer shell of the firebox and a steel casting riveted on around each, these castings being faced to form a joint with corresponding faces on the doors, the two being drawn up tightly together by means of studs and nuts placed all round the outside of the faced joint.

With a view to still further increasing the efficiency of the boiler Mr. Drummond has added a feed-water heating apparatus. No injectors are used for feeding purposes; their place being taken by two duplex-feed pumps arranged tandemwise underneath the boiler in front of the firebox. They are set vertically and fastened to a steel cross stay plate connecting at each end with the main frames. The exhaust steam from the pumps is exhausted into the tender together with that portion of the main exhaust which is required to heat the water in the tank to the desired temperature. The delivery pipes connecting the tender tank and the boiler are carried through the smokebox where the feed water is further heated. The water is, by these combined means, brought to a very high temperature before entering the boiler (hence no injectors) and the pumps are properly regulated to furnish a supply of water uniform with the rate of evaporation. The pumps are kept in operation continuously and are only adjusted to meet changing gradients. It is important to note these features in the design of and arrangements connected with the boiler because hitherto the attempt to introduce the four-cylinder simple locomotive on British railways has been mainly unsuccessful owing to deficient boiler power. In this instance, however, special attention has been given to enlarging the capacity for steam generation, and with such ample cylinder proportions this is above all things necessary.

Mr. Drummond has several 4-cylinder simple engines of the 4-2-2-0 type in service, in which a leading truck precedes two pairs of uncoupled drivers. The cylinders are arranged similarly to those of the engine described above, but in place of the Walschaert gear of the outside cylinders the Joy motion is employed. These locomotives have 6 ft. 7 in. diameter driving wheels, four cylinders 14 in. by 26 in., total heating surface 1,760 sq. ft., grate area 27.5 sq. ft., and steam pressure 175 lbs.

There is also at present building at the Nine Elms Works of the London & South-Western Railway a further series of engines, to the same general design as that illustrated, but having cylinders 16½ in. diameter by 26 in. stroke in place of 16 in. by 24 in. of the "330" class. The slide-valves of the outside cylinders will, in these latest locomotives, work on top instead of below the cylinders.

The general dimensions of the "330" class are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Coal
Tractive effort	25,300 lbs.
Weight in working order	163,520 lbs.
Weight on drivers	114,360 lbs.
Weight on leading truck	48,160 lbs.
Weight of engine and tender in working order	263,984 lbs.
Wheel base, driving	13 ft. 4 in.
Wheel base, engine and tender	53 ft. 2 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.5
Total weight ÷ tractive effort	6.5
Tractive effort × diam. drivers ÷ heating surface	660
Total heating surface ÷ grate area	86.5
Firebox heating surface ÷ total heating surface, per cent	18.6
Weight on drivers ÷ total heating surface	42
Total weight ÷ total heating surface	60
Volume both cylinders, cu. ft	11.2
Total heating surface ÷ vol. cylinders	243
Grate area ÷ vol. cylinders	2.8
CYLINDERS.	
Kind	Simple
Number	4
Diameter and stroke	16 x 24 in.
Valves	Bal. slide
WHEELS.	
Driving, diameter over tires	72 in.
Driving journals, main, diameter	8 in.
Engine truck wheels, diameter	42 in.
Engine truck journals, diameter	6 in.
BOILER.	
Working pressure	175 lbs.
Outside diameter, maximum	67⅛ in.
Firebox, length	114 in.
Tubes, number and outside diameter	340—1¾ in.
Tubes, length	14 ft. 4½ in.
Water tubes, number and diameter	112—2¾ in.
Heating surface, tubes	2,210 sq. ft.
Heating surface, firebox	160 sq. ft.
Heating surface, water tubes	357 sq. ft.
Heating surface, total	2,727 sq. ft.
Grate area	31.5 sq. ft.
Smokestack, height above rail	13 ft. 2½ in.
Center of boiler above rail	108 in.
FEED PUMPS.	
Diameter of steam cylinders	4½ in.
Diameter of water cylinders	3½ in.
Stroke of both cylinders	8½ in.
TENDER.	
Water capacity	4,000 gals.
Coal capacity	4.5 tons
Heating surface of heater	382 sq. ft.

CAST-IRON CAR WHEELS.—There is not another essential part of the freight car equipment which costs the railroad companies so little money compared with the service rendered as does the cast-iron car wheel. The 600 lb. wheel costs about $10.80 new, and after giving a mileage of 40,000 to 70,000 it is turned back to the foundry at a scrap value of about $7.80, giving a cost per 1,000 miles of about 5 cents.—*Mr. W. E. Fowler before the Canadian Railway Club.*

FOAMING WATERS.—For each pound additional foaming matter per 1,000 gallons of water, the increased expense would be equal to the cost of pumping and treating at least 70 gallons of water, and the fuel for heating it to the temperature of boiler water. In addition to this expense, there would be the damage incurred to boilers by introducing cold feed water to replace water blown out, with the consequent cooling of tubes and sheets. —*Report of Committee, Amer. Ry. Eng. & M. of W. Assoc.*

TONNAGE RATING.*

By J. E. Muhlfeld.†

Locomotives suitable for the handling of trains of the greatest permissible tonnage, at the maximum allowable speed over the different operating divisions, should be used and loaded with a reasonable remaining surplus of power to prevent liability of trains failing to make schedule time. Locomotives of great power have too often failed to meet the requirements on account of being attached to trains of greater resistance, as practical experience has now demonstrated that steam locomotives of 70,000 pounds tractive power can be as satisfactorily maintained and operated for hauling freight as those of one-half the capacity.

Speed and grade are factors that largely control the loading of locomotives as well as the cost of their operation. Running speeds of 15, 20 and 25 miles per hour are more economical than speeds of 10, 30 and 35 miles per hour. In general freight locomotives handling low class tonnage should be loaded to haul trains at an average schedule speed between terminals, including road delays, of from 12 to 15 miles per hour, on low grade, and of from 10 to 12 miles per hour on high grade lines, which is as fast as economy will allow. This will require a running speed of 20 miles per hour over a division, except on the ruling grade where they should be loaded to maintain a running speed of 8 miles per hour, unless the grade is over 2 miles in length, when they should be loaded to maintain a running speed of from 10 to 12 miles per hour. On a fairly level division, with considerable curvature, it may be necessary to reduce the loading on the ruling grade in order to maintain 20 miles per hour over the other portions of the division, in which case the rating of the locomotive for 20 miles per hour is the ruling factor. In rating locomotives the tonnage determined upon should be such as will give the same resistance behind the tender, which is not necessarily the same dead weight.

The hauling capacity behind the tender of a simple cylinder freight locomotive, having a ratio of not less than 4 between tractive power and weight on drivers, and operating on straight, level track at a speed of 8 miles per hour may be represented by the following formula:

$$H = \frac{d^2 \times s \times .8p}{D} - 10\ W \text{ in which}$$

H = maximum hauling capacity in pounds at rear of tender at a speed of 8 miles per hour.
d = diameter of cylinder in inches,
S = stroke of piston in feet,
p = indicated boiler pressure in pounds,
D = diameter of driving wheels in feet.
W = weight in tons of engine and tender in working order, including full load of coal and water.
10 = rolling resistance per ton of locomotive in pounds at 8 miles per hour.

From the maximum hauling capacity, so derived, the available hauling capacity, at any desired speed above 8 miles per hour that will give between 250 and 650 feet of piston speed per minute, can be determined by the following formula:

In which $A = H\ [1. - (P - 250)\ .001]$.

In which $P = 56.022\left(\frac{R \times S}{D}\right)$

H = maximum hauling capacity, in pounds, at rear of tender at a speed of 8 miles per hour.
D = diameter of driving wheels, in feet;
S = stroke of piston, in feet;
R = desired running speed, in miles per hour;
P = piston speed, in feet per minute;
A = available hauling capacity of locomotive, in pounds, behind tender at desired speed.

From the available hauling capacity so derived must be deducted a resistance of 2 pounds per ton for each .1 per cent. of grade and 2 pounds per ton for each degree of curvature not compensated, using this adjustment for the combination of grade and curvature that produces the maximum resistance on the division over which the locomotive is to be operated, after which the rating may be calculated as follows:

On a straight, level division, at a running speed of 10 miles per hour, a loaded 100,000 pounds capacity car has a resistance of about 5 pounds and a loaded 60,000 pounds capacity car of about 6 pounds per ton. When empty both cars have a resistance of about 9 pounds per ton. For each 5 miles per hour increase in running speed up to and including 20 miles per hour, 1 pound per ton; for each .1 per cent. of ruling grade, 2 pounds per ton, and for each degree of ruling curvature not compensated 7-10 pound per ton should be added for additional resistance. The adjustment for gradient and curvature should be for such combination as produces the maximum resistance on the division over which the train is to be operated and curves on grades compensated at a minimum of .035 per cent. per degree of curvature can be disregarded.

To allow for the difference in the resistance of empty, partially loaded or loaded cars, the following adjustment figures, which represent the difference in tonnage divided by the difference in number of cars as between the loading for loaded and empty car trains, should be added to the weight of each car:

Minimum	grade	15	tons	per	car
.3%	"	11	"	"	"
.5%	"	8	"	"	"
.75%	"	6	"	"	"
1.00%	"	4	"	"	"
1.50%	"	3	"	"	"
2.00%	"	3	"	"	"
2.50%	"	2	"	"	"

Different ratings should be provided for the following temperature conditions:

The maximum rating for above 45 degrees Fahrenheit.

The next rating for above 35 up to and incuding 45 degrees Fahrenheit. (Add 1 pound per ton to resistance of loaded and empty cars for rating above 45 degrees Fahrenheit.)

The next rating for above 20 up to and including 35 degrees Fahrenheit. (Add 2 pounds per ton to resistance of loaded and 3 pounds per ton to resistance of empty cars for rating above 45 degrees Fahrenheit.)

The minimum rating for 20 degrees Fahrenheit or below. (Add 4 pounds per ton to resistance of loaded and 6 pounds per ton to resistance of empty cars for rating above 45 degrees Fahrenheit.)

With heavy snow or wind, bad rails or locomotives in indifferent condition, special allowance must be made to meet the conditions.

Care should be exercised when the temperature is below 45 degrees Fahrenheit and varies during a 24-hour period that the highest permissible rating is used for runs which occupy the time of day when the most favorable temperature, rail and weather conditions may exist.

In making up trains the loaded and heaviest capacity cars should be placed ahead and house car doors should be closed and locked.

When a helper locomotive is used on a train as a double-header, 90 per cent. of the combined ratings for the locomotives should be used. When a helper locomotive is used as a pusher the combined ratings for the locomotives should be used.

Special rules must be made for special cases, as the combination of speed and load that may give the best result will depend largely upon the density and kind of traffic, length of run, operating limit for length of train, ruling and momentum gradient and curvature, reserve curves, elevation of curves, condition of rail and roadbed, main and passing trackage, water and fuel stations, slow orders, stops, fuel and locomotives.

* From a paper on "Practical Means of Increasing the Earning Capacity of Freight Cars," read before the March meeting of the Railway Club of Pittsburgh.

† General Superintendent of Motive Power, Baltimore & Ohio Railroad.

Coal Used in Steam Heating.—In some tests made by the Gold Car Heating and Lighting Company on the Northern Pacific Railway in extremely cold weather, it was found by catching the drips from the cars, that sixty-two pounds of water per car per hour were obtained. Ordinarily the consumption of steam would not average over fifty pounds. Hence it will be safe to assume that ten pounds of coal are burned on the engine per car per hour, in addition to the regular amount needed for moving the train. With ten-car trains this would be one hundred pounds per hour. If leaks occur in the train pipe, as is sometimes the case, especially at the couplings, the amount will be increased.—*William Penn Evans, before the Pacific Coast Railway Club.*

COMPOSITE HOPPER CAR—DELAWARE AND HUDSON COMPANY.

COMPOSITE HOPPER CAR.

DELAWARE & HUDSON COMPANY.

The American Car & Foundry Company has recently delivered to the Delaware & Hudson Company an order of composite hopper cars of 85,000 lbs. capacity, which are a very good example of a car design in which steel is used wherever it is of particular value and wood wherever it can be placed without affecting the strength or stability of the car as a whole.

The illustrations show the features of the cars very clearly and reference to them will show many well-designed details not mentioned in the following brief general description.

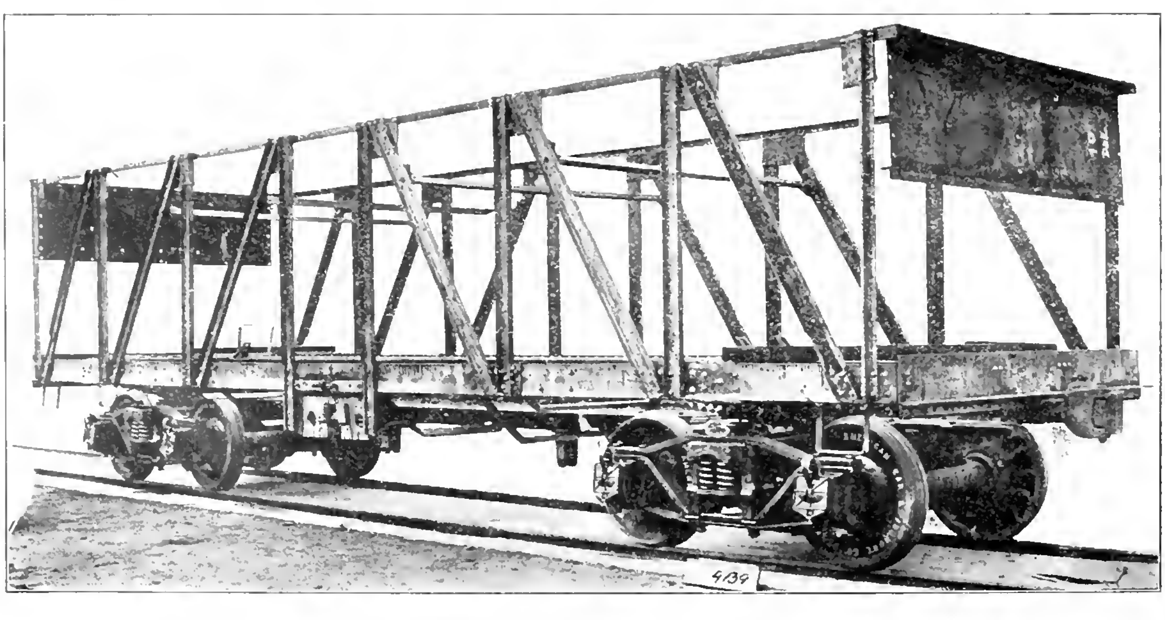
The underframe throughout, with the exception of the end sills, and the principal members of the side framing are formed of steel channels, angles and shapes, while the sides, floors, doors and end sills and posts are of wood. It is of the self-clearing design, with two hoppers, both of which cover nearly the full width of the body.

The load is carried very largely by the center sills, which consist of two 15 in. channel irons spaced 12 7/8 in. apart and extending continuous between the end sills. A 3/8 in. cover plate is fastened to the top of these sills, being continuous between bolsters and a series of diagonal cross ties of 2 x 3/8 in. bars are secured to the bottom of the sills for a short distance inside the bolsters at either end. The sills are set at such a height that the draft lugs are fastened directly to the webs of the channels without the use of auxiliary draft sills. The end sills are formed of 8 x 9 1/2 in. wood reinforced by steel angles and plates, and being but 9 1/2 in. in depth, they pass above the coupler shank without interruption. The side sills are 8 in. channels continuous between end sills and carry a part of the load, which is transferred to them by the hopper supports and the side posts. The bolsters are built up of pressed steel filling pieces between the sills and heavy cover plates top and bottom continuous between side sills, the top plate being 1/2 by 12 in. and the bottom plate 3/4 by 12 in.

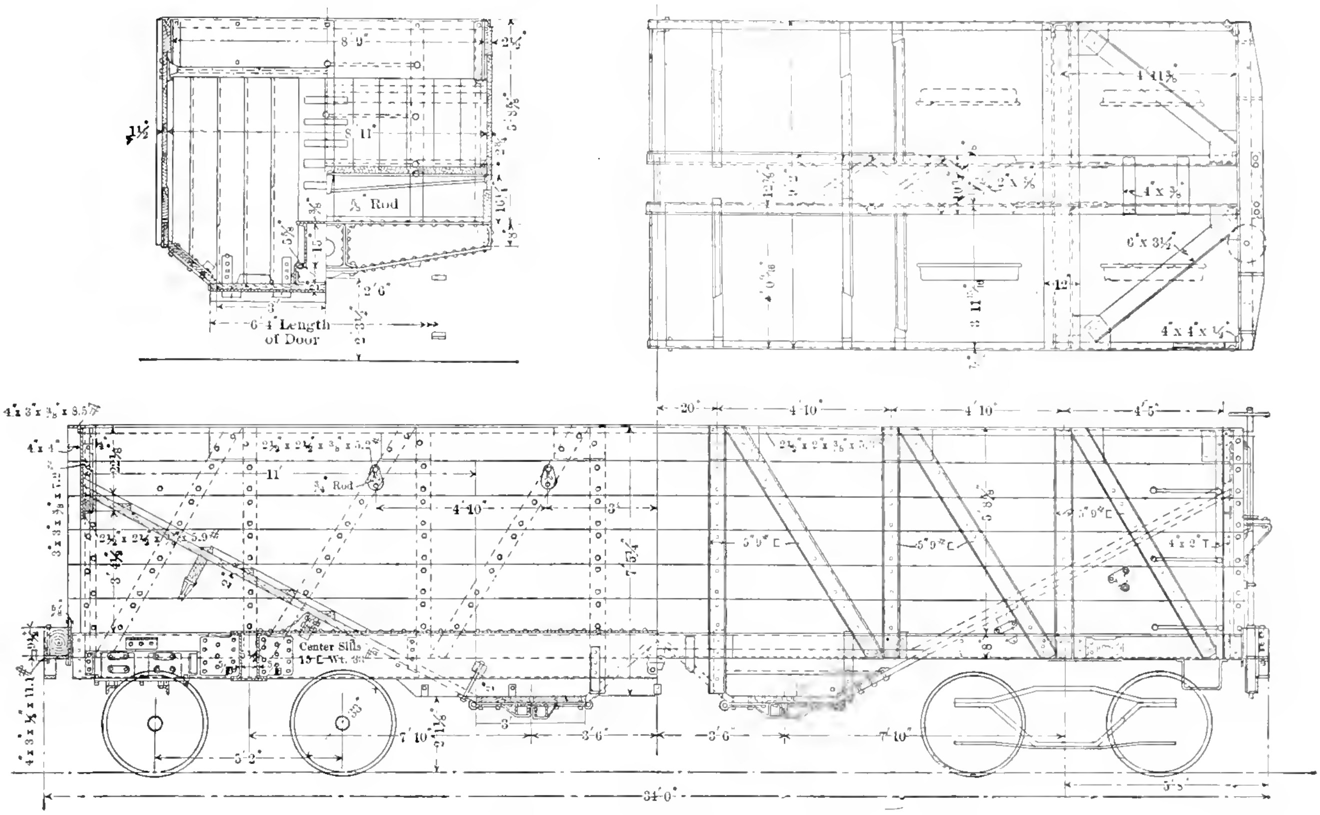
The side framing consists of 5 in. channel iron posts and diagonal members, which connect to a 2 1/2 x 2 in. angle forming the side plate by means of gussets, the corner posts, however, are 4 x 2 in. T-irons and the end plate is a 4 x 3 in. angle. Four stiffening bars, consisting of 2 1/2 x 2 1/2 in. angles covering a 3/4 in. tie rod are placed across between the sides, being located about 17 in. below the plate.

The floor, consisting of 2 in. plank, extends from a point 22 in. below the end plate in one plane to the outer end of the hopper opening on that end, this being 55 3/8 in. below the bottom of the center sills and 2 ft. 1 1/8 in. above the rail. The floor is supported at the upper ends by a cross timber resting on an angle iron, which in turn is secured to a 1/4 in. steel plate forming the end of the car above this point. It is also supported by a cross timber resting on the top of the center and side sills and again by a strap iron sling secured to the side sills and passing below the hopper near the doors. It is further trussed by a 5/8 in. rod located about midway between the upper two supports.

Each hopper has a bottom opening of 3 ft. x 6 ft., which, however, is reduced by the width of the center sills, giving a combined actual opening on both sides of 3 ft. x 4 ft. 4 1/4 in. for each hopper. The hoppers are located 7 ft. apart and have double transverse doors formed of 2 in. plank reinforced by



STEEL FRAMING—COMPOSITE HOPPER CAR.



ELEVATION, PLAN AND SECTIONS OF COMPOSITE HOPPER CAR—D. & H. CO.

plates and bars. The doors are operated by the Dunham drop door device. The method of supporting the hopper is made clear in the general elevation and sections.

The sides, of 1½ in. plank, are fastened inside of the side framing, being bolted to the steel posts. The end posts and auxiliary corner posts of 4 x 4 timbers secured to the steel frame form the end structure of the body.

The trucks are of a simple arch bar design, with cast steel bolsters and Damascus brake beams.

The general dimensions and weights are as follows:

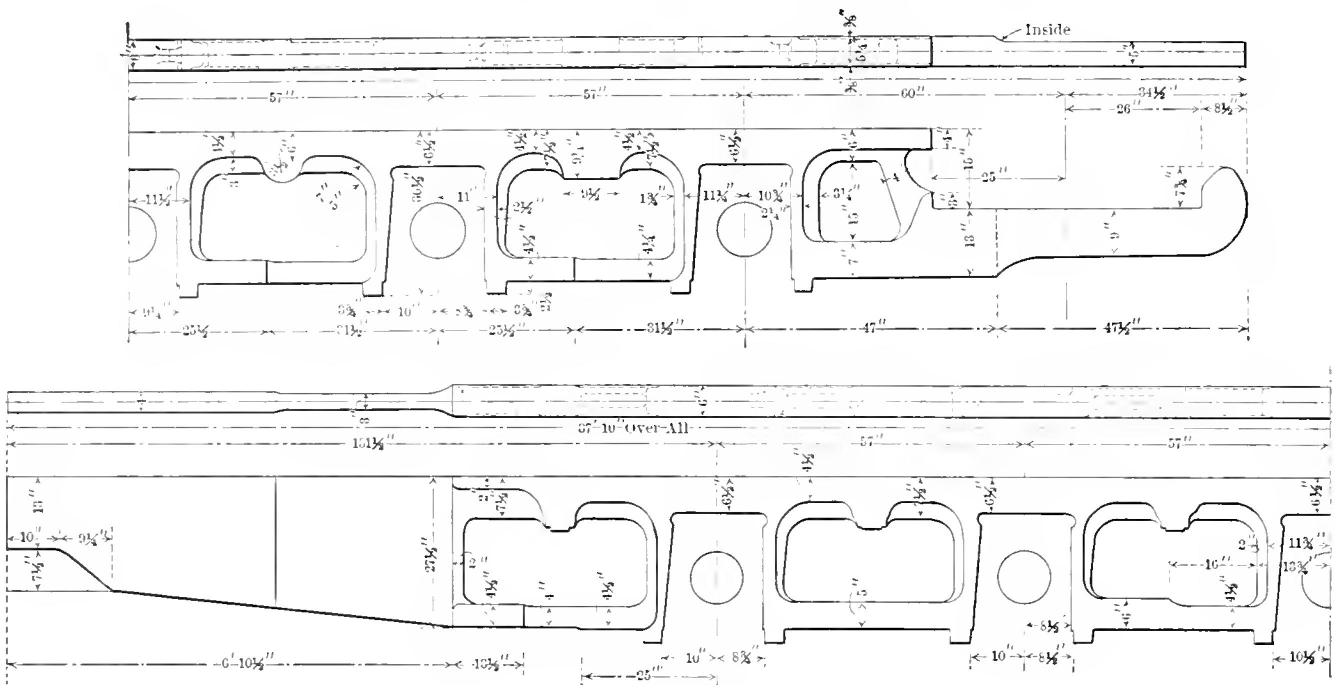
Length over end sills	34 ft.
Width over side sills	9 ft. 2 in.
Length inside	32 ft.
Width inside	8 ft. 11 in.
Height from rail to top of side	9 ft. 6⅜ in.
Height from rail to bottom of center sill	2 ft. 6¾ in.
Distance between bolsters	22 ft. 8 in.
Wheel base of truck	5 ft. 2 in.
Size of wheels	33 in.
Capacity	85,000 lbs.
Weight, light	87,700 lbs.

EUROPEAN LOCOMOTIVE DESIGN.—The following is taken from an article in a recent number of a prominent German engineering paper: One of the first features that causes comment on the part of an American examining these European locomotives is their extreme lightness and apparent delicacy of construction. The piston rods, side and main rods, all parts of the valve gear, as well as the wheels, are made of steel the tensile strength of which is much higher than any material available for such use in the United States. In the latter country, it is not only a question of the expense entailed by the use of such metal, but master mechanics and mechanical engineers are forced to admit that it cannot be procured outside of Europe. Further, in Europe, innovations on locomotives are tried out with the sole end in view of effecting economy of operation, and the enginemen as a rule take more interest in obtaining results and thus gaining premiums for themselves, than is the case in the United States. Hence the complications and cost of repairs for compound locomotives are much less than the coal saving effected by their use. The same is gradually being found out in regard to superheated steam, though it is not so clearly established as compounding, which is now standard practice in Europe.

It must be remembered, however, in considering locomotive performances, that the quality of the coal obtainable in most parts of Europe is excellent, not only the loose coal, but the briquettes that are in common use. While fuel is expensive, it is burned to the greatest advantage owing to the custom of not overloading engines, forcing fires and risking the various kinds of trouble that Americans have come to regard as unavoidable owing to their conditions of traffic.

COST OF THE OPERATION OF MOTOR CARS.—The expense of fuel, repairs, cleaning, etc., runs very uniformly, but with the expense per mile being so largely dependent upon the number of miles run per day, as well as on the wages paid the car crew, comparisons are very unsatisfactory. In actual service cars run, some months, as low as 10 and 11 cents a mile; whereas, cars in other localities will run as high as 16 and 18 cents a mile, and in one case, where a 100 horse-power motor car and trailer has replaced a steam locomotive and train (account of the limited mileage per day), the cost of operation runs as high as 20 cents a mile. On branch lines the motor car should make not less than 100 miles a day. The service of the gasoline motor car is unquestionably different from that of either electric or steam cars. To man the gasoline car with a steam train crew is exceedingly expensive and inadvisable, and does not produce proper results; to man the gasoline motor car with an electric car crew would be equally as unsatisfactory. A well-paid mechanical man to have entire charge and run the motor car, with an assistant to collect tickets, is the best and most economical arrangement possible.—*Mr. W. R. McKeen, Jr., at the New York Railroad Club, Apr., 1907.*

TEAM WORK.—I notice that Mr. Brazier is a man who believes in team work, no matter what department he belongs to. I think that we should teach our men that we have a department in name only. Of course, we look first to our own department, but it should, on the other hand, be a helper of the other departments, and as stated above, a department in name only. We have a great many departments on our railroads, but they all have the same treasurer, and we are all working together to hold the money in the treasury.—*Mr. N. M. Rice before the Railway Storekeepers' Association.*



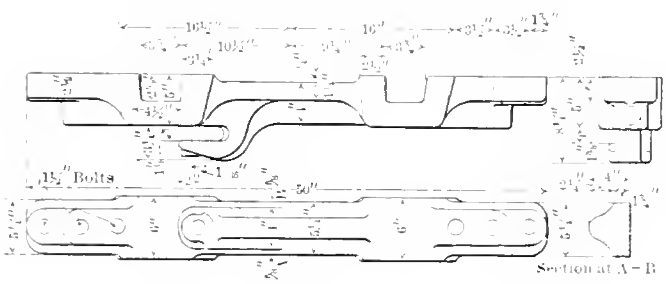
MAIN FRAMES—DECAPOD LOCOMOTIVE—BUFFALO, ROCHESTER AND PITTSBURG RAILROAD.

CAST STEEL FRAME, DECAPOD LOCOMOTIVE.

BUFFALO, ROCHESTER & PITTSBURG RAILROAD.

On page 123 of the April issue of this journal we illustrated, giving general and boiler drawings, a very large simple Decapod locomotive, an order of which is now being built by the American Locomotive Company for the Buffalo, Rochester & Pittsburg Railroad.

These locomotives have 24 by 28 in. cylinders, 52 in. drivers and carry a steam pressure of 210 lbs. The theoretical tractive effort is 55,350 lbs. These figures clearly indicate that special care was necessary to obtain a design of frame which would properly withstand the enormous stresses developed when the locomotive is working at full power, and we give in the accompanying illustration a detailed drawing of the cast steel frame and pedestal binders which are being applied to these locomotives.



PEDESTAL BINDER—DECAPOD LOCOMOTIVE.

It will be seen that while no attempt has been made to carry the I-beam section idea throughout the design, still the metal has been distributed with considerable care and that the T-section is approximated in many places, giving a depth of rail between pedestals of 7½ in., of which 4½ in. is the full width of the frame and 3 in. is narrowed down to 5¼ in. Furthermore the bottom rails between the first and second, and the second and third driving pedestals are made of different widths to accommodate the stresses at these points.

The main frames are of a single casting and measure 37 ft. 10 in. over all, being normally 6 in. wide. The section forming the front rail, which passes below the cylinders, is narrowed to 5 in. in width for most of its length, and is 9 in. deep. The cast steel bumper plate has arms extending inward which are fitted and fastened to this narrowed section of the main frame.

The top front rail is of wrought iron and connects to the main frames by six 1½ in. bolts and three keys, the connection extending over and back of the front driving pedestal.

The pedestal binders are of cast steel of a design clearly shown in the illustration and are arranged for adjustable wedges. They are fastened to the main frame by three 1¼ in. bolts on either end.

ELECTRIFICATION OF STEAM RAILROADS.

At the electrical night of the New York Railroad Club, a brief account of which was given in the previous issue of this journal, Mr. Geo. Gibbs, chief engineer of the Pennsylvania, New York and Long Island R. R., presented a brief paper covering the general proposition of the application of electricity to steam railroads, which, in view of the extravagant claims and prophecies lately being made, is of special interest as portraying a common sense view based on extensive experience and study of all features of the problem. Mr. Gibbs said:

"Among the manifold problems arising for solution in the application of electricity as a motive power for railways, the following appeal to me as especially worthy of our consideration at this time. They are:

Its proper field.

The character of the service to be aimed at.

Its cost.

"The sequence of electric railway development has been from light trolley-car service to heavy interurban; thence to service by trains on city traction systems, in which the speeds and weights approximate those on steam railway lines, and where frequency and volume of service exceed the latter even. Lastly, the application of the new motive power to certain portions of steam railway lines for tunnels, railway terminals and for mountain grade work."

The developments up to date have been logical and the advantages, as measured by the results, sufficient. They are:

1. Means of securing almost unlimited power for traction.
2. Convenient application and control of these means.
3. A motive power well adapted to use in streets and congested centers of population.
4. Increase in average speed for service with frequent stops.
5. Increase in capacity of the line.
6. Cleanliness and attractiveness to the public.
7. Encouragement of travel by reason of the above and of frequent service.
8. Economy of operation in a dense service.

The proposition now advanced is to apply electricity to general railway service. In considering this we should not allow the enthusiasm of the public and electrical engineers to obscure our just perception. Of the electric traction advantages above enumerated it is questionable if many apply to average trunk line service, and if they do in part apply, it is doubtful if the public will largely benefit, and it appears certain that the owners of the properties need not expect to gain greatly thereby.

Trunk line service is to-day conducted, irrespective of the character of the motive power by relatively infrequent and heavy train units, adapted as closely to the public needs as the length of haul, physical conditions, track, safety and reasonable cost of service permits. This may not be the popular belief, but it is a fact, and it is unsafe to assume that railway men are, as a rule, unintelligent and do not strive to supply what the public wants as far as the limitations permit. Electric traction would provide a new motive power, but unless it increases the capacity of the lines, builds up new business which does not now exist, or pays for its adoption by savings in cost, its use is neither logical nor probable.

The cost of inaugurating electric traction on a steam railway line has almost invariably been underestimated. Of its very high cost the public is absolutely ignorant, and to the few railway men who have had occasion to inquire into the matter the figures have appeared staggering and the reasons therefor incomprehensible. I shall not attempt, in this brief talk, to elucidate the matter further than to say that electric traction requires power plants of a capacity to take care of the peak load; the trains must be supplied with motive power, which displaces steam locomotives only and at a much higher cost than the latter; lastly, an expensive continuous contact system over the entire line to supply current from the power plants to the trains. These items foot up to a very heavy total cost per mile of road; but, in addition—and this is a point which is often ignored by estimators —is the fact that electric apparatus cannot be supplied to an existing steam railroad without many changes in its physical features and equipment. These changes amount in some cases to a virtual rebuilding of the line, and, according to my experience, the electric items making up the equipment of a steam railroad under average conditions are from one-half to two-thirds of the total cost only. Furthermore, it may not infrequently result that a steam railway wishing to electrify and to properly adapt its lines to secure the legitimate advantage of same will be found obliged to double its capitalization per mile; this is a contingency which can be complacently faced by few railways, and does not argue for early or wholesale conversion.

I have stated that trunk-line service is likely to continue to be conducted by rather infrequent and heavy train units, a system well adapted to the physical limitations of the property. It appears, therefore, that in adopting electricity at heavy cost we must secure operating savings at least sufficient to offset interest and depreciation charges on the added investment. What are the facts as to this? It has been proven that for a reasonably dense train movement (say suburban), the total cost, including general expense but not capital charges, per car mile of passenger movement will be less for electric than for steam power—for very dense movement substantially less. But in average trunk-line work, both freight and passenger, it will be found that in handling a given traffic electric operation cannot be made to effect nearly enough savings to justify its adoption on this ground; and in suburban service, which is the legitimate field for electric traction, it will require an extremely dense movement, approximately that of the New York Elevated Road and Subway, to effect operating savings sufficient to offset the added charges.

Will, therefore, the introduction of electricity on steam railways cease before it has fairly started? By no means. It will be applied, as Mr. Aspinall has remarked, to make money, not to save it. It will be used in certain large terminals, where reduction of switching will increase capacity, and where safety and cleanliness in tunnels and cities are controlling features, regardless of the great expense. It will be used for heavy mountain grade operation where cheap fuel or water power can be utilized, and powerful electric locomotives may enable the ruling train loads to be taken over the grade without doubling.

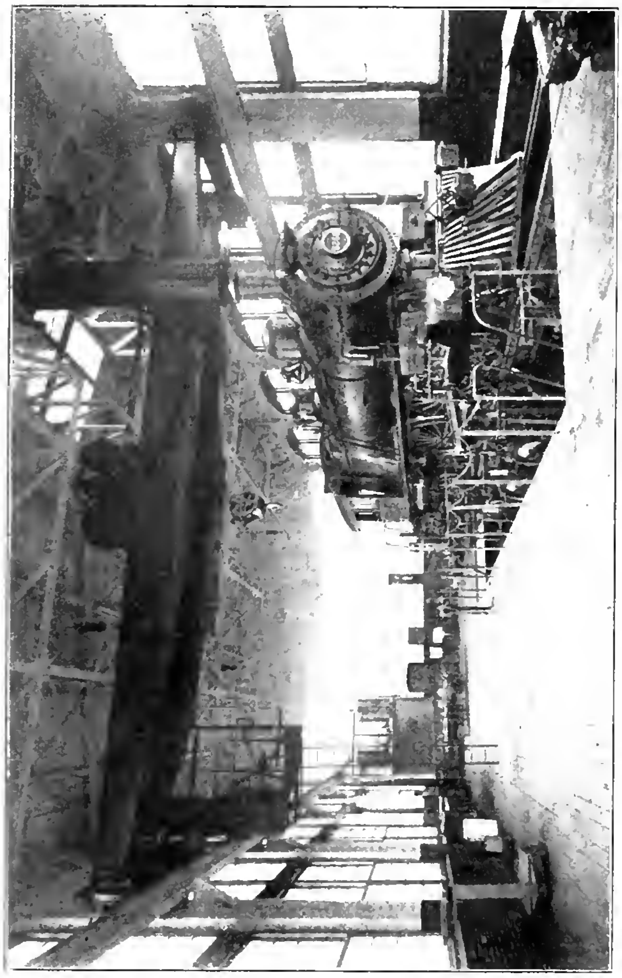
A word regarding character of service, and in this I have especially in mind the popular demand for high speed. Getting there quickly is a vice which is growing upon us. The steam railways are striving to satisfy the demand, and perhaps the statements of railway men as to having reached the limit of capacity in this regard is largely responsible for the rosy promises of electric promoters and the fond hopes of the public. It cannot be too clearly understood that high maximum speed is a function of safety, physical conditions of track, etc. Electric power cannot increase the maximum steam speeds except by altering these conditions. High sustained speed may, in some cases, be attained by electric power, as on a broken gradient and with excessive weights of train, where the possibilities of steam are exceeded, but only at high cost. High average speed in local service with frequent stops is a legitimate field for electric supremacy, and even here a word of caution is necessary.

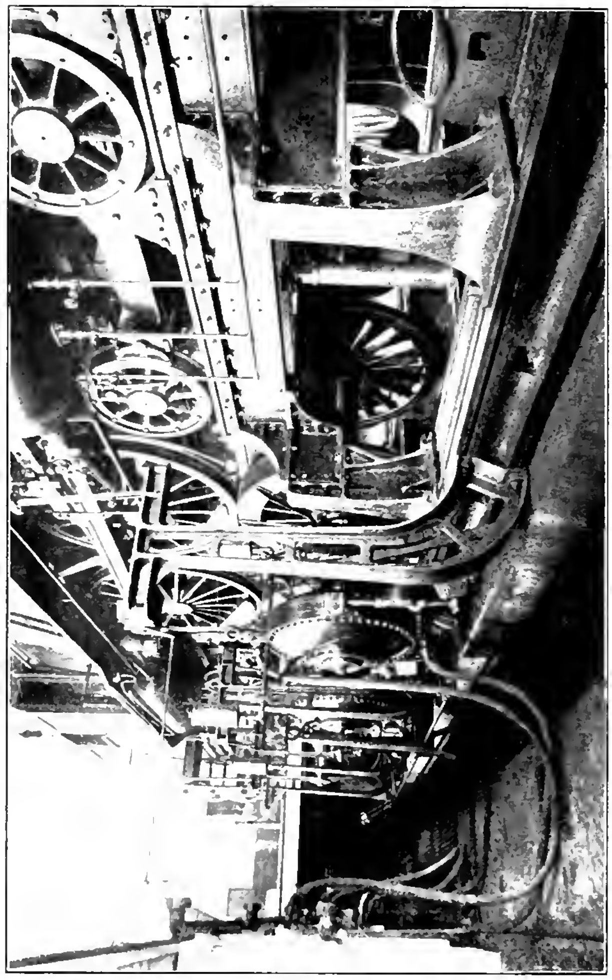
This high average speed is made possible in electric traction by equipping each car with motors, thus consolidating a large amount of power on the train. This means that the train can be accelerated from a stop with great rapidity and the average schedule shortened over the lower starting rates with steam locomotives. The higher the accelerating rate, however, the greater amount of energy consumed during the accelerating period and the higher equipment costs for motors, transmission line and power house, so that we soon arrive at a point where, by striving after speed, economy, reliability, and even safety is sacrificed. We also reach a point where the capacity of the line is affected by increase in speed (because the trains must be spaced farther apart to insure safety), and this means that fewer trains can be despatched over the same track in an hour.

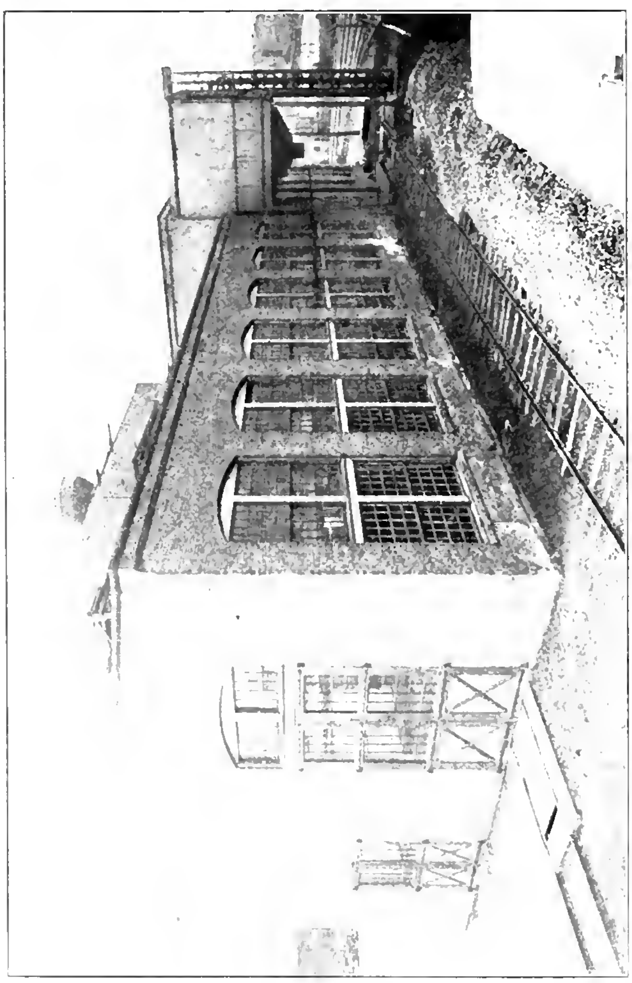
There has been a tendency for the public to generalize on the advantages of electric traction from too few examples, and this tendency promises to work injustice and hardship to the railroads unless the growth of electric traction is guided along rational lines. It is certain that heavy electric traction work may be called in the tentative stage at present, and its development must be accomplished for some time to come at heavy cost to the pioneers. Its introduction, as in the case of the terminals in New York City, is sometimes a public and operating necessity, but these conditions do not obtain to like extent in smaller centers of population, and the cost of the introduction elsewhere for like purposes may be easily a crushing burden.

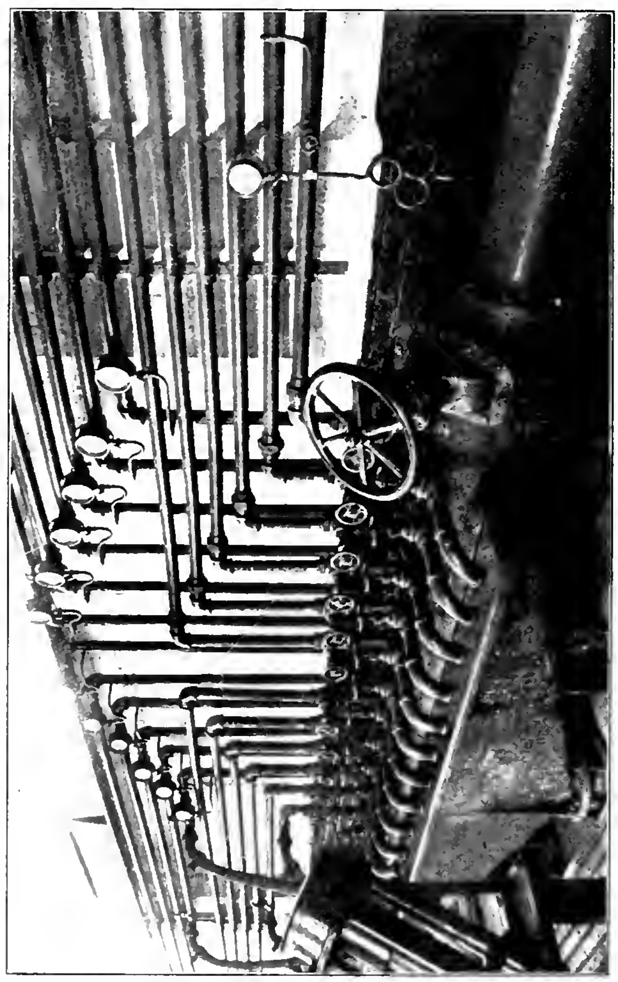
Summing up, if the statements above briefly advanced are well founded, it appears that electric traction has solved the city and suburban transportation problem for rapid, convenient and safe movement of a dense traffic; it has been found adaptable to the special conditions of terminal, tunnel and heavy grade work. It has not yet proven its advisability for the movement under trunk-line conditions of long distance heavy train units at infrequent intervals, because of its very high first cost, and because of the lack of stability in methods and appliances for economically and reliably conducting the service. In my opinion the time is far distant when we are ready to discard, even to an appreciable extent, the time-tried steam locomotive in this service; and when the time does come, it will be through a radical change in methods from any of those heretofore advanced.

STANDARD LOCOMOTIVES REDUCE OPERATING COSTS.—In the early eighties, Mr. N. W. Sample was superintendent of motive power of the Denver & Rio Grande Railroad, then narrow gauge. Under his direction the road used but three classes of locomotives, passenger, freight and switching. The parts of the switching locomotives were largely interchangeable with those of the passenger and freight, and the tenders of all were alike. Mr. Sample purchased cylinders, frames and rods from the Baldwin Locomotive Works and kept his rolling stock continuously in service, reducing the cost of operation, including wages, fuel, repairs and all supplies to sixteen cents per train mile. When the road was changed to standard gauge (1882-1887) the cost of operation only increased to eighteen cents per train mile.—*Arthur L. Church in "Record of Recent Construction," No. 60.*







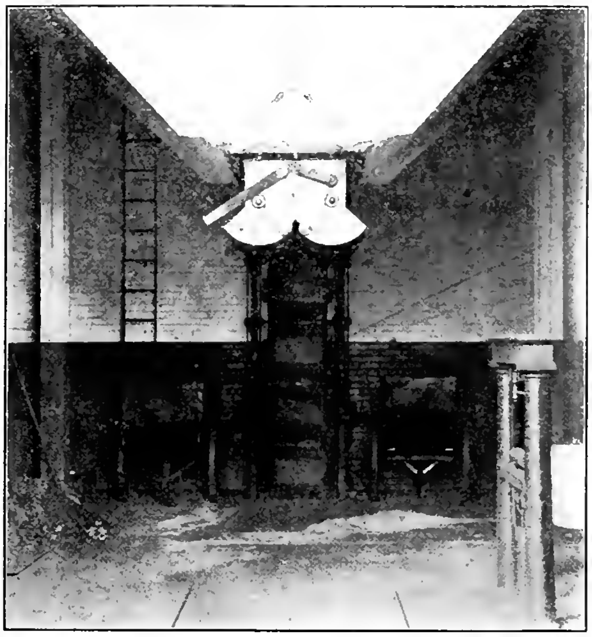


PENNSYLVANIA RAILROAD LOCOMOTIVE TESTING PLANT AS INSTALLED IN ITS PERMANENT QUARTERS AT ALTOONA, PA.

LOCOMOTIVE TESTING PLANT.

PENNSYLVANIA RAILROAD.

The locomotive testing plant, on which so large an amount of valuable data was obtained at the St. Louis Exposition, is, as was mentioned in our February issue, now in operation at Altoona. The plant is housed in a steel and brick building, specially constructed for the purpose, an exterior view of which



BOTTOM OF COAL SUPPLY BIN.

is shown in one of the illustrations. Advantage has been taken of the experience gained from the operation at St. Louis and a few minor changes have been made in the installation at Altoona, with the result that the plant now operates without any of the difficulties which caused so much delay and trouble during the former tests.

The construction of the testing plant, its dynamometer and other apparatus, was illustrated and described in detail in the April, 1905, issue of this journal, page 127. There have been practically no changes made in the apparatus described at that time and reference can be made to that article for the general features and details of the plant.

The accompanying illustrations show several views of the present arrangement and it will be seen that ample provision has been made for good light, ventilation, convenient location of instruments, special facilities for handling and weighing coal and ashes, protection of the recording mechanism from any disturbing conditions, etc.

It will be remembered that one of the most troublesome features of the operation at St. Louis was the difficulty in obtaining a supply of water for the friction brakes at a constant pressure. In the present installation this difficulty has been entirely removed by the use of a two-stage centrifugal pump driven by a 75 h.p. electric motor, which is fitted with an automatic control and delivers water at a constant pressure of 75 lbs. to the main header, from which the branch pipes for the individual brakes are led. The pump draws its supply from one of the large water tanks nearby, the temperature of which is sufficiently low for this purpose. The discharge from the brakes empties into an iron trough, which is shown in one of the illustrations. From this it runs by gravity into a tank located beneath the floor of the building, from which it is again forced back into the outside tank by another centrifugal pump driven by a 20 h.p. electric motor. This apparatus is capable of delivering a large volume of water at low pressure, which is needed for high speed tests, and it has a capacity of 900 gallons per minute. The automatic features for maintaining a constant pressure have proved to be a success and there has been no difficulty with sudden fluctuations of water pressure.

The dynamometer has been placed somewhat farther away from the locomotive than was the case at St. Louis, thus allowing more room for the firing platform. It has also been enclosed in a small steel and concrete housing, which protects it from the dust and dirt occasioned by the handling of coal and ashes in the immediate vicinity.

For handling the coal for the locomotive a very complete plant has been installed. The loaded coal cars are run in on the track alongside the building and dumped into a hopper below the track level. From this hopper the coal is carried by a bucket conveyor to two elevated reinforced concrete pockets, each of which has a capacity of 50 tons. These pockets are located over the larger of the two rooms directly back of the testing laboratory and each is provided with a bottom cut-off gate, of a type shown in one of the illustrations. The coal is discharged from the bins into wagons holding 1,000 lbs. each, which are run over the weighing scales and then pushed along a passage way beneath the laboratory floor to a hydraulic elevator, which raises them to the firing platform, where the cars are dumped. The ashes are discharged from the locomotive into the bottom of the pit, from which they are shoveled into a wagon and after being weighed are raised in the hydraulic elevator to the level of the main floor and emptied into a chute leading to a conveyor, which delivers them to an ash bin on the outside track. From this they can be discharged into cars and hauled away.

The water for boiler use is taken from a supply tank in the corner of the laboratory, which is filled from one of the large outside tanks, the water being passed through the weighing tanks, from which it is discharged into the supply tank. It also passes through a meter on its way to the injector, the reading of which is used as a check upon the weighing tanks. The overflow from the injectors is collected and returned to the supply tanks by a small motor driven centrifugal pump.

The spark collecting apparatus has been greatly improved over the one originally used in St. Louis, and after much experimenting an arrangement has been devised which collects as large a proportion of the sparks as it is possible to get without seriously obstructing the draft. This entire apparatus is carried from a truck supported on run-ways above the roof of the building and is adjustable over a distance of 16 ft. 6 in. The opening in the roof is protected by a hood, which keeps it closed to the weather at all times.

The smaller of the two rooms located back of the laboratory proper is arranged for the computers and here the tests are worked up as soon as completed.

Some changes have been made in the foundations of the plant, which provides better drainage than it was possible to obtain at St. Louis. The system of piping has also been more carefully worked out and arranged, but in other respects the plant remains practically as originally built.

Tests have been completed on a Pennsylvania simple Atlantic type locomotive, and it is stated that the plant is at present turned over to the United States government for use in connection with the testing of briquettes as locomotive fuel.

COST OF LOCOMOTIVES.—The following table gives the weights and prices of locomotives in 1885 and 1905. As the only available weight in many cases is with the locomotive in working order, the price per pound is figured from the total weight of the engine with three gauges of water in the boiler, but excluding the tender.

WEIGHTS AND PRICES OF LOCOMOTIVES 1885 AND 1905.

1885.	Weights.	Price.	Price per lb.
American Type	80,857	$6,695	$0.0828
Mogul Type	72,800	6,662	.0912
Ten Wheel Type	85,000	7,583	.0892
Consolidation Type	92,400	7,888	.0854
1905.	**Weights.**	**Price.**	**Price per lb.**
American Type	102,000	$9,410	$0.092
Atlantic Type	187,200	15,750	.083
Pacific Type	227,000	15,830	.070
Ten Wheel Type	156,000	13,690	.088
Consolidation Type	192,460	14,500	.075

—*William Penn Evans before the Pacific Coast Railway Club.*

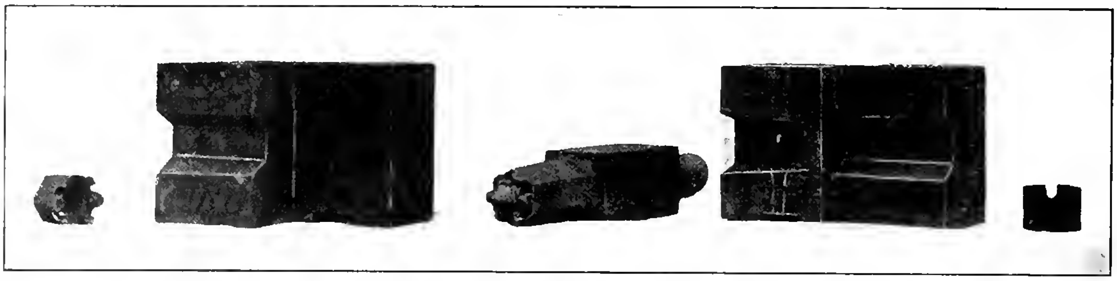


FIG. 1. DIES AND HEADER FOR MAKING BRILL NUTS.

FORGING AT THE COLLINWOOD SHOPS.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

In April and June of last year, on pages 142 and 235, articles were presented on forging at the Collinwood shops. Since these articles appeared several new dies and headers have been made for use in connection with the Ajax forging machines, which are of interest. Ferguson oil furnaces are used for heating the iron.

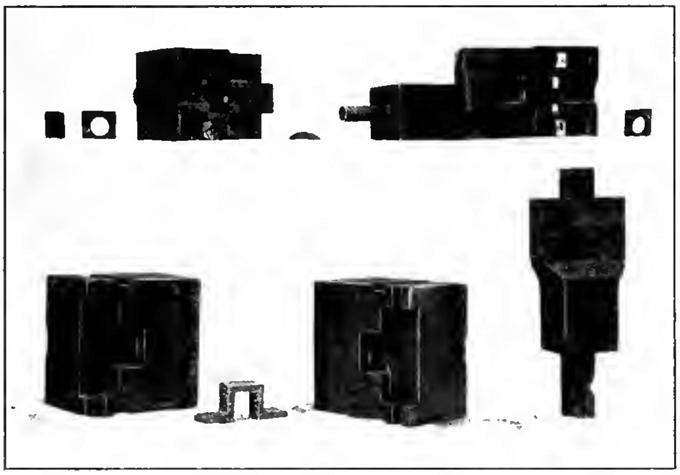


FIG. 2. DIES AND HEADERS FOR MAKING WASHERS AND A SIMPLE FORM OF BUCKLE.

One of the most interesting of these is a set of dies and header used on the 3½-in. Ajax machine for making a lock nut which is used very extensively on the Lake Shore and is shown in the accompanying illustration. This nut is made in one operation. As the two dies move toward each other and close up a piece is sheared off the end of the hot bar and the header or plunger closes in forming the nut as shown and indenting it in the center to guide the drill. When the nut leaves the forging machine it is only necessary to grind off the thin fins and drill and tap it. As the nuts may be made practically as fast as it is possible to heat and feed the bar into the machine their cost is very low.

The second illustration shows two sets of dies and headers. The upper ones are for forming and punching washers which are used on passenger cars for tie and brace rods. This washer, as may be seen from the one lying between the die and the header, is flat on one side and rounded on the other. It is made from ½ x 1¾-in. flat iron. Each half of the die is made in two parts. The sliding part, which shears the bar, is guided by a pin and by two screw bolts which work in slots. One-half of the die is shown with the shear open and the other half with it closed. The heated bar is put in from the top and the two halves close together, gripping the iron. When the ram or plunger strikes, both of the shears are forced back, shearing the

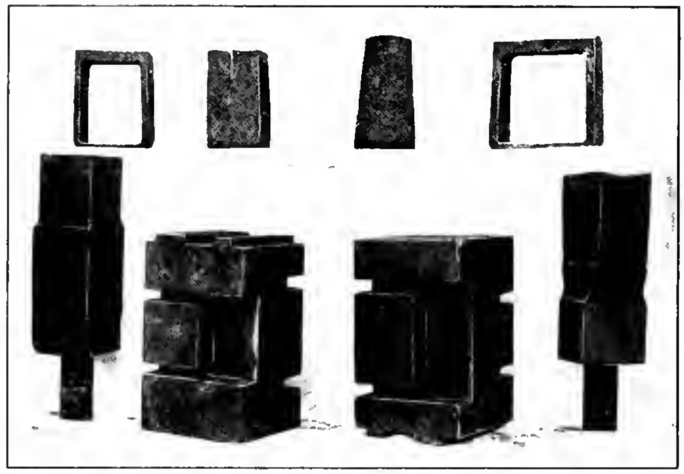


FIG. 3. DIES AND HEADERS FOR FORGING SPRING BANDS.

piece of iron, rounding it and punching the hole all in one operation.

In the lower half of the photograph are shown the dies and header for making a simple form of buckle. The stock is placed in position, the two dies come together, grip the stock and the plunger bends and shears the metal in one operation.

Tools for forging spring bands are shown in Fig. 3. These bands are made from 4 x ⅝-in. merchant bar iron. The spring band is first bent so as to lap the iron at the heavy portion of the band. The piece is then heated to a welding heat and is placed between the dies and completed at one stroke of the ram.

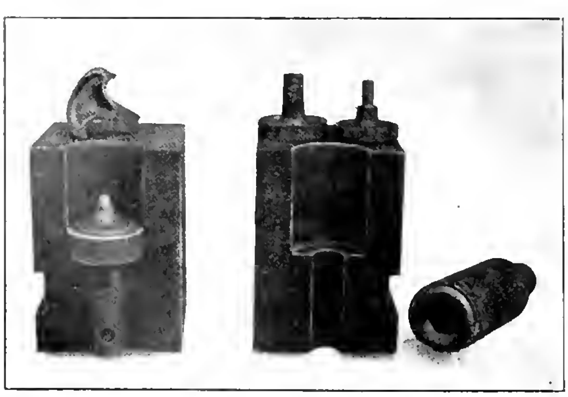


FIG. 4. DIES AND HEADER FOR VACUUM RELIEF VALVE.

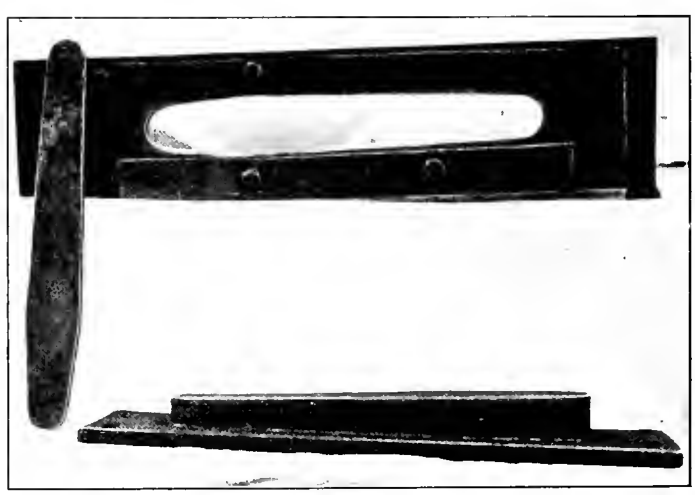
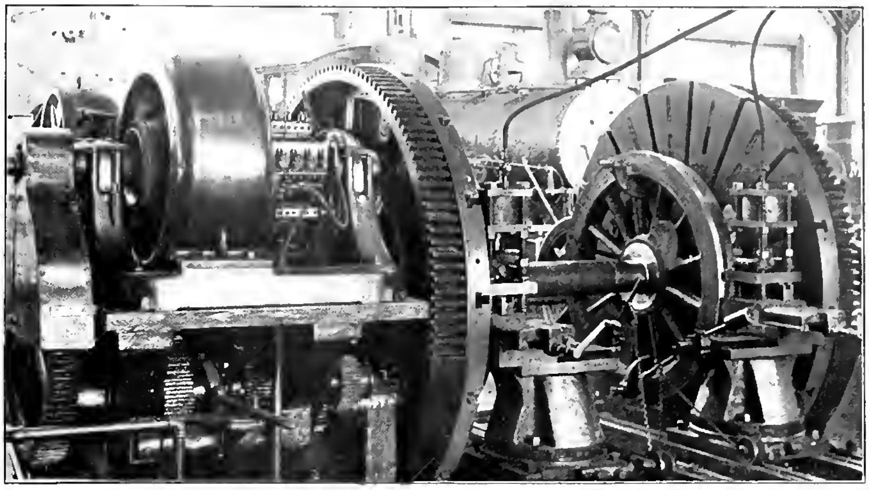


FIG. 5. PUNCH AND DIE FOR SHEARING BRAKE LEVERS.

The vacuum relief valve shown in Fig. 4 is made from 1-in. steel bar in two operations. The valve is first headed similar to a round head pin and the stock is sheared off to the desired length. It is then heated and at one stroke of the machine is completed by means of the dies and header shown in the illustration. The valve is half a pound lighter than the standard brass valve used for this purpose.

A punch and die for shearing brake levers are shown in Fig. 5. These tools have been used on one of the large bulldozers for a considerable time. They are made of cast iron and faced with steel plates. Commercial bar iron is ordered of the proper length for the levers and of a width equal to the widest part. The lever is formed with one stroke of the machine with only a small waste of material.

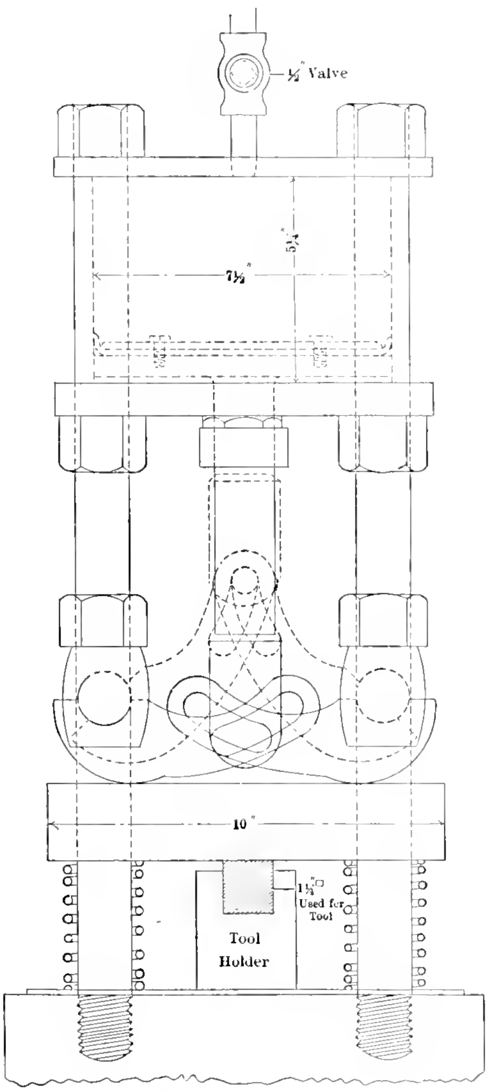


PNEUMATIC TOOL HOLDER ON DRIVING WHEEL LATHE.

PNEUMATIC TOOL HOLDER FOR WHEEL LATHE.

The accompanying illustrations show a pneumatic attachment for holding the cutting tools on a driving wheel lathe, which is giving very satisfactory service in the Grand Rapids shops of the Pere Marquette Railway.

This attachment was designed by Mr. F. C. Pickard, machine foreman of the shops, and by its use the time of changing tools in the lathe has been reduced from an average of five minutes to one minute and in addition all difficulty with broken studs, slipping wrenches, etc., has been eliminated. When it is considered that ordinarily the tools are changed five or six times while turning one pair of tires, it can be seen that the time saved by the use of this device is considerable.



PNEUMATIC TOOL HOLDER.

The construction is clearly shown in the illustrations. The air cylinder, which is connected to the carriage by four long stud bolts, is 7½ in. diameter and has a stroke of 5¼ in. The piston rod connects to two cam levers which force the tool holder plate down onto the tool, against the resistance of the four springs. The tool is in a holder consisting of a bar of steel 3 x 2½ in. and of the proper length, which is slotted to take a 1¼-in. square tool. The tool projects above the holder about ¼ inch and the tool plate bears directly on its top surface. When the air is released the tool plate is forced up ½ inch, giving ample room to remove or adjust the tool.

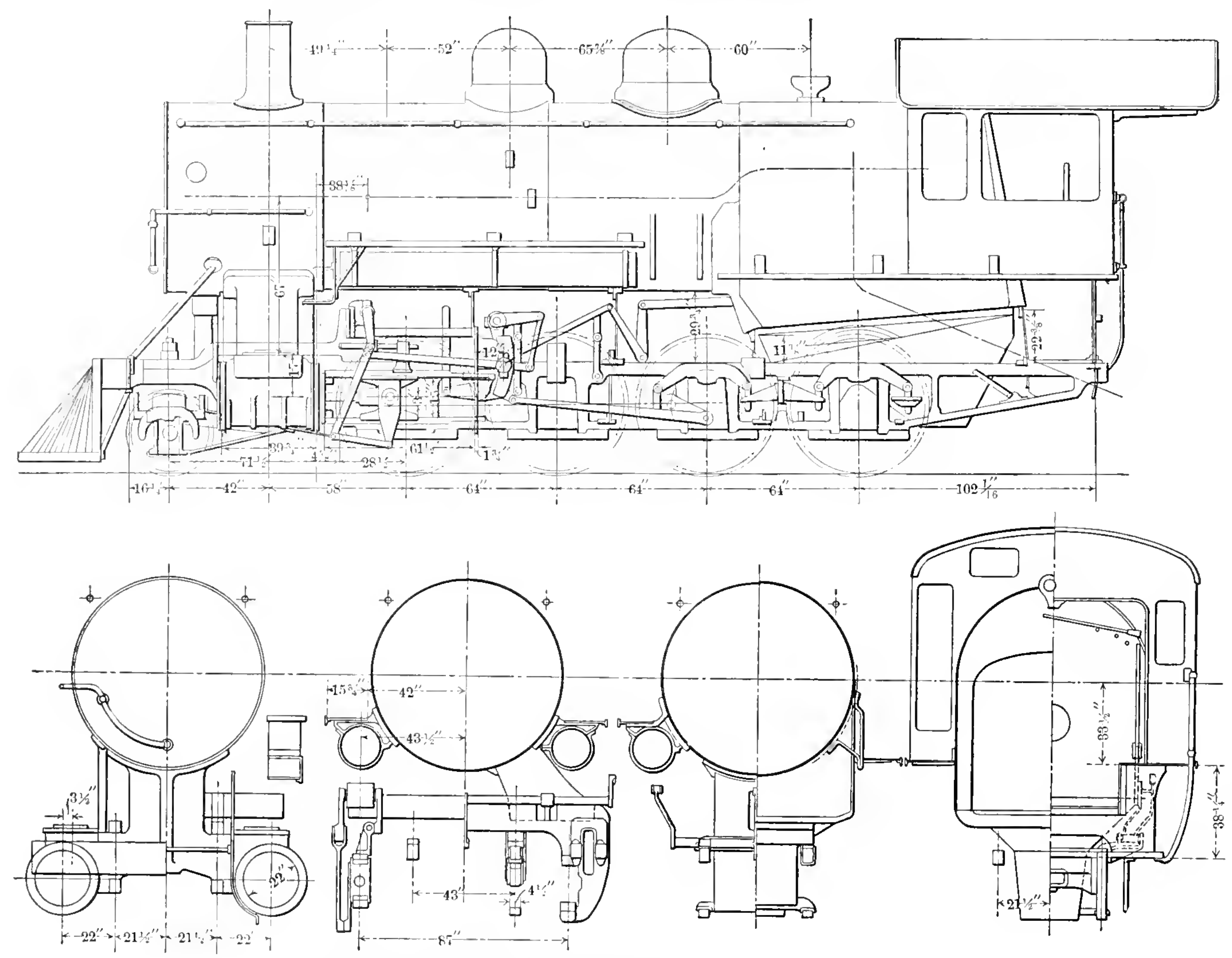
We are indebted to Mr. W. J. Haynen, former superintendent of shops at Grand Rapids, for the illustrations and description.

DEDICATION OF THE ENGINEERING SOCIETIES BUILDING.

The building of the Engineering Societies, at 29 W. 39th street, New York, was dedicated with appropriate exercises, beginning Tuesday, April 16. Mr. Andrew Carnegie, whose gift of $1,500,000 made possible this building and the structure of the Engineers' Club adjoining it on 40th street, was present and made a short address. The other speakers at the first meeting were Mr. Charles F. Scott, president of the A. I. E. E., and the chairman of the building committee; Mr. E. E. Alcott, president of the United Engineering Society, which is a holding organization of the building, and Dr. Arthur T. Hadley, president of Yale University. On the evening of April 16 a joint reception was held, the receiving parties consisting of the presidents of the three founder societies, at which time the entire building was thrown open for inspection. The following day the exercises were continued, consisting of addresses by the presidents of the three founder societies and presentation of medals for distinguished service to Ralph W. Pope, Frederick R. Hutton, and Rossiter W. Raymond, secretaries and past secretary of the several societies. The John Fritz gold medal was presented to Alexander Graham Bell at this meeting. Dr. James Douglas, past president of the Institute of Mining Engineers, also delivered an oration on the subject of "Ethics of Secret Processes in the Arts." Professional sessions of the founder societies were also held during the same week.

RESULTS OF PROPER SHOP MANAGEMENT.—In one of the shops of the Northwest where a proper system of shop management has been in conscientious operation for four or five years, the time of general repairs has been reduced from one month to thirteen days.—*William Penn Evans before the Pacific Coast Railway Club.*

The power efficiency of certain soft coals when used in the gas-producer plant is two and one-half times greater than when used in an ordinary steam-boiler plant.



ELEVATIONS AND SECTIONS, CONSOLIDATION LOCOMOTIVE—C. S., N. O. & P. R. R.

SIMPLE CONSOLIDATION LOCOMOTIVE.

COLORADO SOUTHERN, NEW ORLEANS & PACIFIC RAILROAD.

The Baldwin Locomotive Works are delivering an order of 26 consolidation locomotives to the Colorado Southern, New Orleans & Pacific Railroad, which are an excellent representation of recent practice in heavy single expansion freight engines. The design includes a large straight boiler 78 in. in diameter with 22 x 30 in. cylinders, having balanced slide valves actuated by the Walschaert type of valve gear. The driving wheels are 57 in. in diameter and the tractive effort is 43,300 lbs. The locomotives are estimated to weigh 182,000 lbs. on drivers and 207,000 lbs. total. This gives a factor of adhesion of 4.2, which is about the average figure for this class of locomotive.

These locomotives are very similar to the common standard consolidation locomotives of the Harriman Lines,* differing from them, however, in having slide instead of piston valves and in having a 78 in. in place of an 80 in. boiler. The heating surface is also much less, due to the smaller number of tubes, which are also but 14 ft. 6½ in. in length instead of 15 ft. In other respects, however, the two designs are very much alike except for the valve gear.

The boiler, as mentioned above, is of the straight type with a sloping throat sheet and back head. The mud ring is inclined toward the front and is supported on buckle plates bolted to frame cross ties. It is of cast steel and measures 5 in. in width all around. The barrel contains 386 2 in. flues, which give a heating surface of 2,939 sq. ft. The firebox contains 183 sq. ft. of heating surface, being 5.85 per cent. of the total heating surface. The grate area of 51 sq. ft. gives 1 sq. ft. of surface to every 61 sq. ft. of total heating surface, a figure which indicates that with an average grade of bituminous coal no difficulty should be found in obtaining sufficient steam without forcing the fire to an uneconomical rate of combustion.

The frames are of cast steel and measure 4½ in. in width. They have double front rails spanning the cylinders.

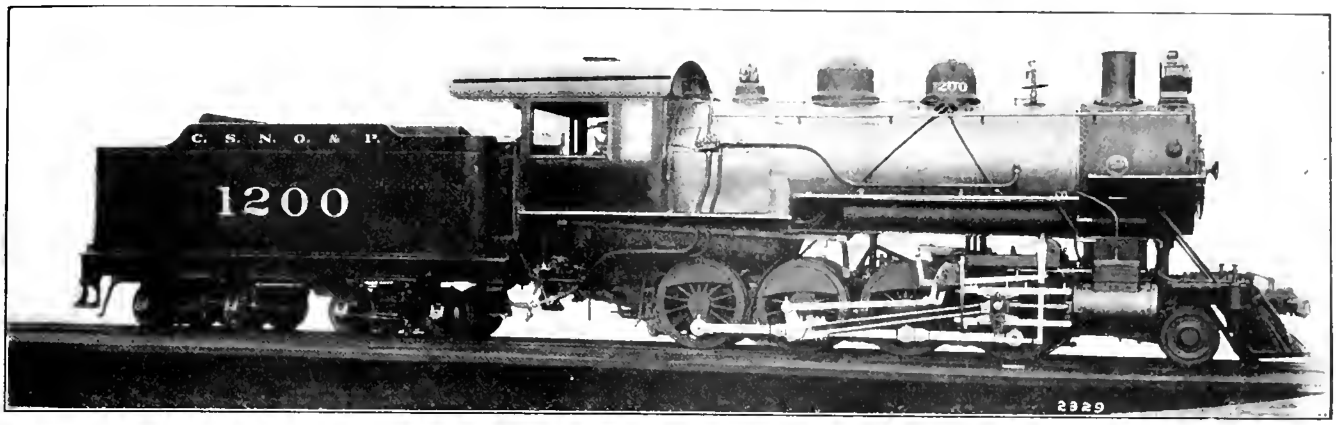
The general features of the design of Walschaert valve gear applied to these locomotives are quite clearly shown in the illustrations. The use of slide valves necessitates the transferring of the motion from the plane of the valve gear, which is outside of the guides, to a point 3½ in. inside the cylinder center, and this has been accomplished by the use of a rocker arm supported in bearings forming part of the frame cross tie, which is bolted to lugs cast in one piece to the upper front frame rail. This rocker shaft has two downwardly extending arms, the outer one being connected to a combination lever and the inner one by a cross head connection to the valve stem, which is supported and guided by a bearing resting on the top guide bar. Two reverse shafts are required in the design, the forward one being supported in bearings bolted to the guide yoke and the other one, which connects to the reverse lever, resting on the frame. It will be noticed that the eccentric rod connects to the link at a point which gives a shorter leverage than has been common in previous designs, and hence requires less eccentricity in the return crank for the same valve movement. It will also be noticed that there is a brace between the front cross tie and the guide yoke, which will be of material assistance in stiffening both, and in keeping the valve gear in better adjustment.

The general dimensions, weights, and ratios of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal

* See AMERICAN ENGINEER, 1905, pages 154, 200, 250, 288, 320, 353 and 441.



CONSOLIDATION LOCOMOTIVE—COLORADO SOUTHERN, NEW ORLEANS AND PACIFIC RAILROAD.

Tractive effort	43,300 lbs.
Weight in working order, est.	207,000 lbs.
Weight on drivers, est.	182,000 lbs.
Weight on leading truck, est.	25,000 lbs.
Weight of engine and tender in working order, est.	355,000 lbs.
Wheel base, driving	16 ft. 0 in.
Wheel base, total	24 ft. 4 in.
Wheel base, engine and tender	56 ft. 3 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.20
Total weight ÷ tractive effort	4.76
Tractive effort × diam. drivers ÷ heating surface	790.00
Total heating service ÷ grate area	61.00
Firebox heating surface ÷ total heating surface, per cent	5.85
Weight on drivers ÷ total heating surface	58.20
Total weight ÷ total heating surface	66.00
Volume both cylinders, cu. ft	13.20
Total heating surface ÷ vol. cylinders	236.50
Grate area ÷ vol. cylinders	3.87
CYLINDERS.	
Kind	Simple
Diameter and stroke	22" × 30"
Kind of valves	Bal. Slide
Type of valve gear	Walschaert
WHEELS.	
Driving, diameter over tires	57 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10" × 12 in.
Driving journals, others, diameter and length	9 × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	5½ × 10 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	78 in.
Firebox, length and width	108 × 68 in.
Firebox plates, thickness, side	5/16 in.
Firebox plates, thickness, back	⅜ in.
Firebox plates, thickness, crown	7/16 in.
Firebox plates, thickness, tube	½ in.
Firebox, water space	5 in.
Tubes, number and outside diameter	386—2 in.
Tubes, length	14 ft. 6½ in.
Heating surface, tubes	2,939 sq. ft.
Heating surface, firebox	183 sq. ft.
Heating surface, total	3,122 sq. ft.
Grate area	51 sq. ft.
Center of boiler above rail	115½ in.
TENDER.	
Frame	Steel Channels
Wheels, diameter	33 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	7,500 gals.
Coal capacity	12 tons

WATER PURIFICATION.

The report of the Committee on Water Service, which was presented at the last convention of the American Railway Engineering and Maintenance of Way Association, contains a formula for determining the point at which it will pay to treat foaming water. This section of the report is as follows:

If natural water containing 10 grains of foaming solids has this quantity raised to 20 grains by using soda ash as a reagent, there would be a minimum of 20 per cent. water wasted to keep it below the critical point, while only 10 per cent. would be wasted if treated with barium hydrate. Therefore, the grains increase per gallon of sodium sulphate caused by using soda ash as a reagent represents the minimum per cent. of water wasted in changing boiler water over what would be wasted if water was not softened, or if barium hydrate was used as a reagent. The minimum waste would be represented by the total cost of pumping and treating this wasted water by soda ash plus the cost of the fuel required to raise this water from the temperature of feed water to the temperature of the water in the boiler.

For an increase of one pound foaming matter per thousand gallons of feed water, it would be the total cost of pumping and treating 70 gallons of water, and the fuel for heating it to temperature of boiler water. For any other increase per thousand gallons of water, the minimum cost would be directly proportional to this.

The following equation is given to show the point where the benefits derived from treating the water will just balance the cost of treating:

X = Number of hundredweight (100 pounds) of solids removed from water per annum.
B = Money value of benefits received from removing 100 pounds of solids. This will include:
Saving in boiler washing and repairs.
Saving in fuel.
Increased service received from locomotives, represented by the interest on the cost of additional number of locomotives that would be required to perform the service rendered by locomotives using the soft water, if based on the performance prior to treating the water.
C = Cost per 100 pounds of solids removed to operate the plant, as follows:
Additional cost of labor.
Additional cost of fuel and power.
Cost of chemicals.
Cost of current repairs.
D = Cost of plant installed.
I = Interest per annum on D.
L = Estimated useful life of plant in years.
R = Estimated value of materials recovered from plant after L years.
S = Annual depreciation of plant, equivalent to a sum per year, which, if placed in a sinking fund at I rate of interest, would amount to D — R in L years. (See table, page 16, Kent's pocket book.)

The benefits would just balance the cost when

$$X B = X C + I + S.$$
$$X = (I + S) \div (B - C).$$

The number of pounds solids removed daily to make benefits just equal the cost would be

$$\frac{I + S}{3.65 \, (B - C)}$$

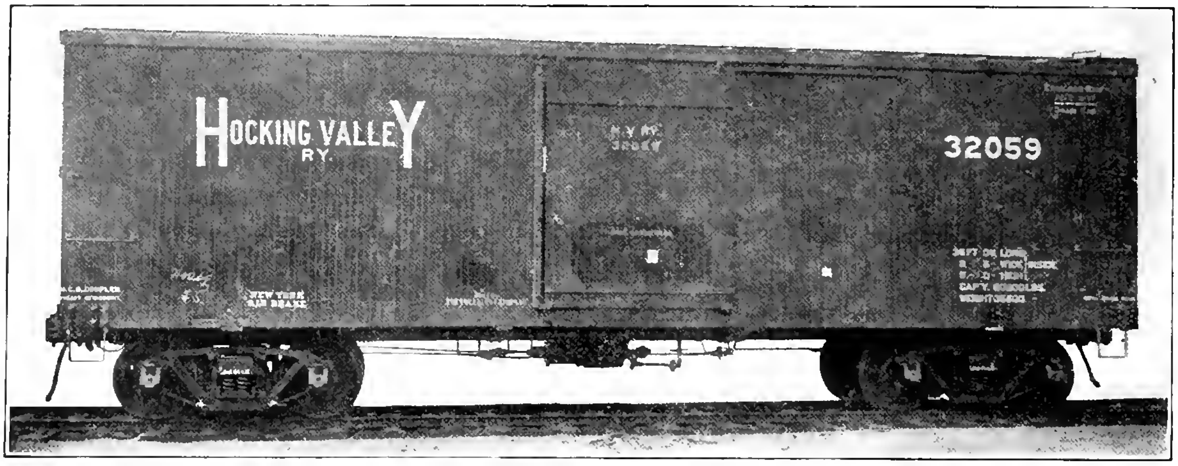
If more than this amount of solids is removed the plant will be profitable to the company.

Values for B can only be fixed for each particular case, as some of the matter held in solution is much more injurious than the same weight of other matters. The mechanical department of each railway should be able to approximate the values, knowing the proportions of the injurious matter in the water.

Meeting of the Air Brake Association.—The fourteenth annual convention of this association will be held in Columbus, Ohio, beginning Tuesday, May 14, 1907. The convention headquarters will be at the Great Southern Hotel. This date is one month later than the regular meeting and it is believed that it will be a better time for holding the convention than in April.

Meeting of the Association of Transportation and Car Accounting Officers.—Upon the urgent request of a considerable number of members of the Association of Transportation and Car Accounting Officers, the executive committee has favorably considered the question of changing the date of the annual meeting, so that this assembly will be held in St. Paul, Minn., Tuesday and Wednesday, June 25th and 26th.

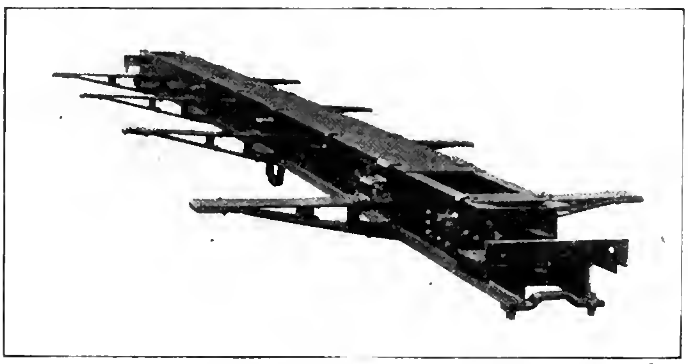
If "subscriber" of Baltimore will send in his name and address we will be glad to furnish him the information requested.



BOX CAR WITH RALSTON STEEL UNDERFRAME.

STEEL UNDERFRAME FOR FREIGHT CARS.

A very urgent and general demand for freight car equipment, during the past few years, with the resulting congestion of orders at the car building companies and their inability to give early deliveries, has led many of the railroad companies to build as large a part of the new freight equipment as possible at their own shops. While most railroad car shops are in a position to construct wooden freight equipment, comparatively few of them are able to turn out steel, or composite cars, with reasonable economy or rapidity. In the present state of affairs, in which so large a proportion of the cars in service are of all steel, or equipped with a steel underframe, it is almost necessary to have at least a steel underframe, in freight cars, in order to get a reasonable length of service out of them.



RALSTON STEEL UNDERFRAME.

Recognizing these conditions the Ralston Steel Car Company has designed a type of steel underframe, which it is prepared to furnish complete to suit the specifications of the road, and on which the railroad shops can easily erect a wooden superstructure, giving a composite car capable of standing rough usage and at the same time permitting the railroads to build cars in their own shops, and thus obtain quick delivery.

This underframe is shown in the accompanying illustrations and is designed to have its greatest strength in that part of the car where it is most needed for taking care of shocks due to rough handling, as well as for supporting the rated capacity of the car. The center sill is a heavy box girder built up of channels with top and bottom cover plates extending continuous between the bolsters. The bolsters and needle beams are built up with the one-piece tension members passing through the webs of the channels and the compression members passing below the center sill. Filling pieces are provided between the two members, securing them to the center sills and to each other. These filling pieces are malleable iron castings. The channel center sills are continuous from end sill to end sill and are notched and bent over at the end, forming a pocket and support for the wooden end sill. This point is further reinforced by the addition of a buffer angle riveted to the underframe and bolted to the end sill.

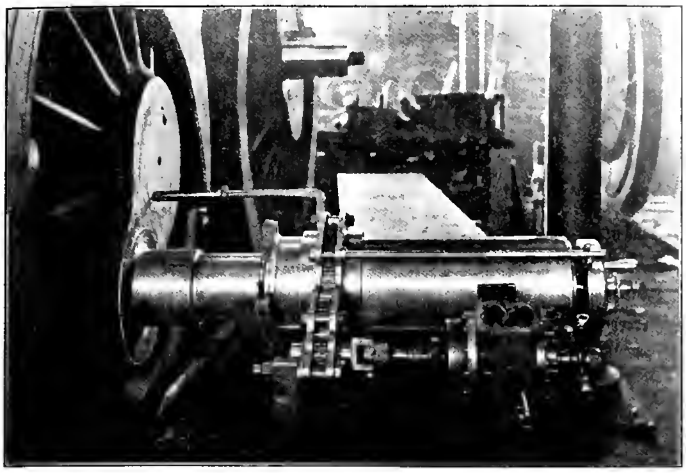
This type of underframe is also furnished as a repair feature and is supplied to railroad companies for application to cars requiring heavy repairs. Slight changes are made in the design for such conditions and it is usually to fit the regular body bolster, if that is of metal, to the new underframe. An example of the underframe, as thus used for general repairs, is shown in the illustration of the Kanawha & Michigan Railway gondola car.

The Ralston Steel Car Company is now completing an order of 1,500 underframes for the Pullman Company, a large part of which are being applied to some 60,000 lb. capacity box cars for the Hocking Valley Railway. An example of these cars is also shown in one of the illustrations.

Economical Tonnage.—It must be borne in mind that the most economical tonnage for a locomotive is not always its maximum tonnage. For any given division there is a certain combination of speed and tonnage for each class of engine used that will give the most economical results. When this combination has been determined any further saving must come from the introduction of heavier power.—*William Penn Evans before the Pacific Coast Railway Club.*

Self-Clearing Coal Cars Profitable.—Self-clearing cars can be unloaded into a hopper for at least six cents a ton less than the cost of unloading flat bottom cars by hand. Using 15 per cent. per annum of the original cost as the cost of the plant, an expense of $146 is justified to save handling one ton a day by hand.—*Report of Committee, Amer. Ry. Eng. & M. of W. Assoc.*

RALSTON STEEL UNDERFRAME AS A REPAIR FEATURE.



PORTABLE CRANK PIN TURNING MACHINE ASSEMBLED.

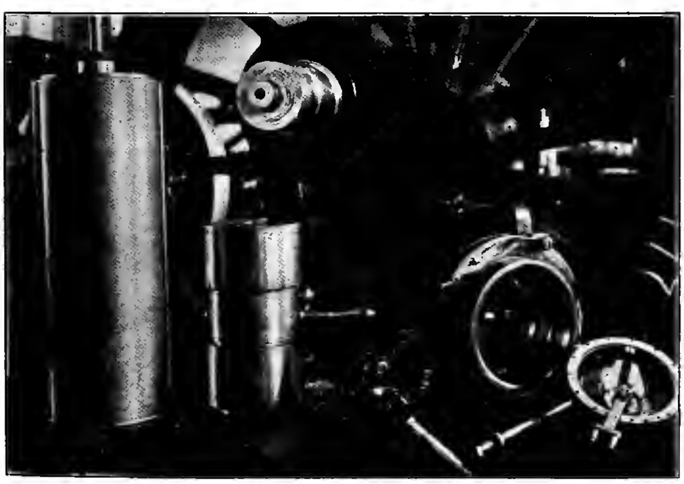
PORTABLE CRANK PIN TURNING MACHINE.

There has been in use for some time past on the Grand Trunk Railway several portable machines for turning crank pins, which were designed by Mr. M. H. Westbrook, machine shop foreman, at the Port Huron shops. These machines have proved to be most successful in every way and not only save a large amount of time and money in truing up crank pins which absolutely require attention, but also have been found to be so convenient that the pins are maintained in much better general condition since the machine is as readily available for use in the roundhouse as in the shop.

The accompanying illustrations show the machine as assembled and also the various parts. It will be noticed that it consists of comparatively few pieces, all of which are light in weight, permitting the machine to easily be put up by one man or his helper.

It is fair to assume that the crank pin stud and the outer end face of the pin will always maintain their shape and size, and hence a machine which operates from an adjustment taken at this point will bring the pin when turned, with its faces parallel to the original face and in exact quarter. This machine operates on this principle and hence should turn out perfectly satisfactory work.

The center bearing of the machine, which is shown with two handles attached in one of the illustrations, is screwed on the end of the crank pin stud by means of these handles until it takes a bearing against the face. The handles are then removed



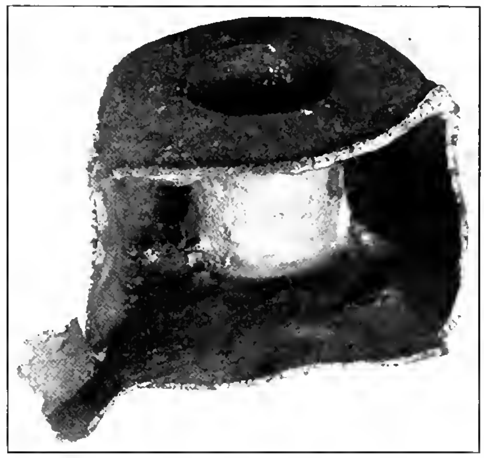
PORTABLE CRANK PIN TURNING MACHINE DISMANTLED.

and the sleeve shown at the left hand is slipped over the barrel on which it has a bearing. Attached to the inner end of this sleeve are four lugs for carrying the tools for roughing, finishing and filleting the crank pin. These tools are of 5/8 in. round, high speed steel. The gear wheel and casing are then slipped over the two feather keys on the sleeve and the air motor is connected.

The feed of the sleeve is accomplished through a mechanism contained in a hand wheel attached to the outer end of the sleeve, which works on a feed spindle fastened to the stationary center bearing. The feed can be either automatic or by hand, as desired, it being possible to change from one to the other without stopping the motor. Provision has been made for taking up any lost motion, due to ordinary wear and tear, between the barrel and the sleeve, by adjustable rings, which are screwed against taper split bushings on either end.

REMARKABLE COUPLER CASTING.

The accompanying illustration shows a bottom lug broken from a coupler while in service on the Mexican Central Railway. This proved to be a most remarkable freak casting and consisted simply of a shell of steel 1/8 in. thick, which gave no evidence from the exterior of any defect. Although there are a large number of couplers of the same make in service on that



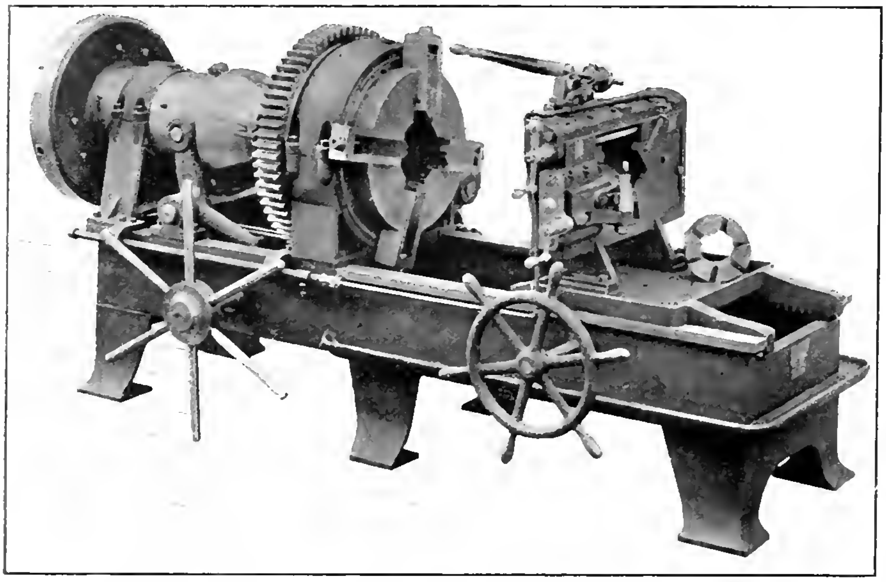
road, none of the others have been found to be defective in this manner, and it is no doubt one of those unexplainable occurrences which occasionally are found in castings of all kinds.

MOTOR CARS FOR BRANCH LINES.—Branch lines collect freight traffic and feed the main line, and the limited passenger business, of course, can be handled economically when turned over to the main line. Thus it is, if the steam train could be replaced by a combination motor car, a great saving could be made in the operating expenses. Passenger traffic which would be insufficient to fill a steam train in most cases would justify the operation of a gasoline motor car. Frequency of service could be given the public, which, of course, is much appreciated. The number of trips, cost of operation, etc., is entirely dependent upon the density of traffic and the length of the branch line. On steam railroads in direct competition with the frequent service of electric lines, a motor car of higher power is necessary to obtain the rapid acceleration and high speed required for this class of service. However, with these high-power engines there seems to be no particular increase in the cost of operation, as larger engines work more economically per horse-power developed than the the smaller ones. These cars are an entirely new style of transportation medium, and should be constructed, not along the conventional lines of an electric car, a steam passenger coach or railroad locomotive, but should be designed on entirely new lines; in other words, on lines particularly adapted for this new class of service.—*Mr. W. R. McKeen, Jr., before the New York Railroad Club.*

DIFFERENT LOCOMOTIVE DESIGNS.—There are in existence at the Baldwin Locomotive Works something like 4,900 designs of cylinders, 2,000 of driving boxes, 10,000 of springs, 3,800 of rods and 7,300 of boilers, to all of which new designs are being added daily. The list might be extended indefinitely.—*Arthur L. Church in "Record of Recent Construction," No. 60.*

A NEW PIPE THREADING AND CUTTING MACHINE.

A new size of pipe threading and cutting off machine, known as the P. D. Q. C. No. 6, has recently been brought out by the Bignall & Keeler Mfg. Co., Edwardsville, Ill. The machine is particularly adapted for shops having large quantities of pipe of one size to thread at one time. It is equipped with a quick operating chuck, controlled by a hand wheel and pinion which engages in a segment gear on the end of the cone shifting arm. The cone slides freely on the arbor; as it is moved forward rollers on the ends of the chuck jaw arms roll up on the surface of the cone, and the arms being thereby spread apart tighten the jaws on the pipe. The gripping chuck can be operated while the machine is running and the jaws being once set for a



BIGNALL & KEELER NEW PIPE THREADING AND CUTTING MACHINE.

given size of pipe, an entire lot can be threaded without stopping the machine. The steel jaws in the chuck are graduated, which facilitates the setting for a given size of pipe.

The die head is of the Peerless type, as used on the machines of similar type manufactured by this company, in which the dies can be instantly released from the pipe after the pipe is threaded. The cutting-off tool is held in the slide on the front of the die stand and a reaming tool for removing the burr from the pipe is also provided.

The rear chuck is provided with three independent jaws with which fittings can be made up, and also a bushing for holding the pipe central without gripping the pipe.

The drive is from a four-step cone pulley at the back, which in connection with compound shifting gears affords eight changes of speed. The machine can be arranged to be driven by belt or motor. An automatic oil pump in the bed of the machine supplies oil to both the dies and the cutting-off tool.

The machine illustrated occupies a floor space of 50 x 120 in., and weighs in the neighborhood of 7,500 lb. Ten other sizes of the machine are made, ranging in pipe capacities from 1¼ to 6 in. in diameter, inclusive.

Front End Netting for English Locomotives.—Smokestacks of locomotives in Great Britain are not supplied with screens to prevent the emission of sparks and big burning cinders. Such a device is used, however, for traction engines employed for agricultural purposes. Complaints of burning cinders have been very numerous this year, and it is suggested that the English railway managers should immediately adopt spark arresters, such as are used in the United States.—*Industrial World.*

Frank Thomson Scholarships.—A fund of $120,000 has been deposited with a trust company which will act as trustee, the income of which will be used to furnish scholarships of $600 a year each, open only to sons of employees of the Pennsylvania Railroad. Competitive examinations will be held, the winners of which, if satisfactory in other ways, can attend any college or technical school desired. Two men will be chosen this year, two more the following year, etc., finally making eight men who will be kept in college by this fund.

Cost of Locomotive Operation.—In a contributed discussion on the subject of "Electric vs. Steam Locomotive," printed in the March proceedings of the Amer. Inst. Elect. Engineers, Mr. W. S. Murray gives some figures obtained from tests and records of freight and passenger locomotives operating on the New York division of the New York, New Haven & Hartford R. R. It is shown that in express passenger service the average pounds of coal per indicated horse-power hour was 4.06 and in local passenger service it was 4.68. This includes all the coal burned divided by the total horse-power hours for 18 days' service, these being based on the average horse-power obtained from careful tests over the division. The number of pounds of coal per revenue ton mile for express, local and freight trains is .194, .335 and .169 respectively. The cost of repairs for freight engines, which apparently covers about 10 locomotives for one year, was 6.68 cents per mile and the cost of maintenance is 1.42 cents per mile, giving 8.1 cents per mile total for repairs and maintenance. The figures for passenger locomotives are 3.88 cents repairs, 1.72 cents maintenance and 5.6 cents total. Mr. Murray concludes that, "for mixed freight and passenger service the same gross draw-bar pull can be produced by the single-phase method of traction for 60 per cent. of the coal required by the steam method of traction," and that, "locomotive repairs are between three and four times as great for steam as for electric locomotives." The source of the figures for electric traction are not given.

IMPROVED HOSE CLAMP.

The accompanying illustration shows a new and improved clamp for air, water or steam hose, which has been designed and patented and is being manufactured by the Thompson Manufacturing Company, Newark, Ohio. It will be seen that this clamp can be made of heavier material than is commonly used, because it does not have to be sprung apart in order to be placed over a hose, the fittings of which are already in place. It is made of three parts, of which the connecting bolt forms one, the two parts of the clamp being interlocked, as is clearly shown

IMPROVED HOSE CLAMP.

in the illustration. It is easily evident that the larger section of the clamp can be slipped over the hose without injury to either and the smaller piece then hooked into place, resulting in a clamp which can be drawn up very tightly without danger of breakage. It can, of course, be removed without deforma-

tion and hence is practically indestructible. These clamps are made in sizes from ½ in steam hose to 3½ in tank hose and are made of galvanized cold rolled steel.

PERSONALS

Mr. G. W. Mudd has been appointed master mechanic of the Denver & Rio Grande Railway at Alamosa, Colo.

Mr. W. R. Davis has been appointed road foreman of engines of the Toledo & Ohio Central Railway at Columbus, Ohio.

Mr. J. D. Crawley has been appointed master mechanic of the Georgia, Florida & Alabama Railway, with office at Bainbridge, Ga.

Mr. C. P. Diehr has been appointed master mechanic of the New York Central & Hudson River Railroad, with office at Avis, Pa.

Mr. Tabor Hamilton has been appointed master mechanic of the Cumberland Valley Railroad, at Chambersburg, Pa., succeeding Mr. J. B. Divens.

Mr. Walter E. Hooton has been appointed chief clerk of the motive power department of the Santa Fé Central Railway at Estancia, New Mexico.

Mr. Henry C. Manchester has been appointed assistant superintendent of motive power of the Maine Central Railroad, with office at Portland, Maine.

Mr. J. R. Donnelly has been appointed superintendent of motive power of the Canada Atlantic Ry. (Grand Trunk System), with office at Ottawa, Ont.

Mr. W. Kennedy has resigned as master mechanic of the Grand Trunk Railway, at Toronto, Ont., to accept a position with the Great Northern Railway.

Mr. R. L. Stewart has been appointed master mechanic of the Kansas City Southern Railway, with office at Pittsburg, Kan., succeeding Mr. W. B. Dunlevy.

Mr. F. Burke has been appointed general foreman of shops ot the Toledo & Ohio Central Railway, at West Columbus, Ohio, succeeding Mr. W. R. Davis.

Mr. Bert Myers has been appointed acting road foreman of engines of the Erie Railroad at Huntington, Ind., in place of Mr. J. A. Cooper, transferred.

Mr. A. C. Adams has been appointed master mechanic of the Pennsylvania Division of the Lehigh Valley Railroad, with office at Sayre, Pa., succeeding Mr. John McMullen.

Mr. J. B. Diven has been appointed assistant engineer of motive power of the New Jersey grand division of the Pennsylvania Railroad, with headquarters at Jersey City, N. J.

Mr. W. F. Girten has been appointed general storekeeper of the Central Railroad of New Jersey, with headquarters at Elizabethport, Pa., succeeding Mr. H. S. Hoskinson, resigned.

Mr. David M. Perrine has been appointed superintendent of motive power of the new Western Pennsylvania Division of the Pennsylvania Railroad, with headquarters at Pittsburg, Pa.

Mr. George Donahue has been appointed master car builder of the New York, New Haven & Hartford Railroad, with office at Readville, Mass., succeeding Mr. F. D. Simpson, resigned.

Mr. P. Z. Zang has been appointed master mechanic of the Worcester Division of the New York, New Haven & Hartford Railroad, with office at Providence, R. I., succeeding Mr. Donahue.

Mr. D. M. Wallace has been appointed to succeed Mr. Perrine as superintendent of motive power of the Philadelphia and Erie Railroad Divison of the Pennsylvania Railroad, with headquarters at Williamsport, Pa.

Mr. L. J. Miller, division foreman of the Missouri Pacific Ry., at Atchison, Kan., has been appointed master mechanic of the northern Kansas and Omaha divisions, excepting the Kansas City Northwestern R. R., with office at Atchison, Kan.

Mr. W. G. Wallace has been appointed to the new office of superintendent of motive power of the Detroit, Toledo & Ironton Railroad and the Ann Arbor Railroad, with headquarters at Toledo, Ohio. The office of master mechanic of these roads has been abolished.

Mr. A. J. Cromwell, for many years superintendent of motive power of the Baltimore & Ohio Railroad, and an important factor in locomotive building, died at Baltimore, April 9, at the age of 76 years. Mr. Cromwell entered the company's employ 45 years ago as a machinist and rose in the ranks until he became head of the motive department. He designed many improvements for locomotives and planned the engines which established the 45-minute schedule between Baltimore and Washington. He retired several years ago.

Mr. W. J. Tollerton, formerly superintendent of motive power of the Chicago, Rock Island & Pacific Railroad at Topeka, Kan., has been appointed to the new office of assistant general superintendent of motive power. In connection with this appointment Mr. J. B. Kilpatrick has been appointed superintendent of motive power of the Central District, with headquarters at Chicago; Mr. W. J. Harrison has been appointed superintendent of motive power of the Northern District, with office at Cedar Rapids, Ia.; Mr. S. W. Mollinix has been appointed superintendent of motive power of the Southwestern District, with office at Topeka, Kan.; Mr. C. M. Taylor has been appointed superintendent of motive power of the Choctaw District, with headquarters at Shawnee, Okla., and Mr. F. W. Williams has been appointed superintendent of motive power of the Southern District, with office at Ft. Worth, Texas. The superintendents of motive power will report to the assistant general superintendent of motive power and will make such reports and perform such duties as are required by the general superintendent of motive power and will be subject to the direction of the latter in matters of shop practice, standard plans, etc. The assistant general superintendent of motive power will report to the general manager.

BOOKS

Mineral Resources of the United States.—U. S. Geological Survey Report for the calendar year 1905. Government Printing Office, Washington, D. C.

This report covers over 1,400 pages, giving an immense amount of valuable and accurate information concerning the mineral resources of the United States. The larger part of the book deals with coal and oil, on which subjects complete statistical data of all kinds, as well as much general information, including anaylsis of many different samples, are given.

The Theta-Phi Diagram. Applied to Steam, Gas and Oil Engines. By Henry A. Golding, A. M. I. Mech. E., 123 pages. 5 x 7 in. Cloth. Published by the Technical Publishing Company and issued through D. Van Nostrand Co., 23 Murray St., New York. Price, $1.25.

This is the second edition of this book, first issued in 1898, in which the author stated that "of the utility of the temperature-entrophy diagram, in representing the various thermal changes which take place in all heat motors, there cannot be any doubt." The author has presented the subject with as little mathematics

as possible, largely using the graphical method by means of which the principles are much more simply explained. In brief, the Theta-Phi diagram is of value for representing the thermal changes which take place in all heat engines and can be very easily represented graphically as well as mathematically. The indicator diagram is a rough example of this class of diagram, although it does not show the reception and distribution of all the heat. This book will be found to explain the subject and the practical value of the diagrams very clearly.

Locomotives: Simple, Compound, and Electric. By H. C. Regan. Fifth Edition. 917 pages. 5½ x 8 in. Cloth. Published by John Wiley & Sons, 43 E. 19th St., New York. Price, $3.50.

The last edition of this well-known and valuable book on locomotives has been revised to bring the subject strictly up to date. Much matter on the electric locomotive has also been added. The principles of generating and transmitting apparatus and method of application have been explained. In brief, the book is a practical treatise of the locomotive engine and its operation. The subject has been carefully sub-divided, each part being handled separately, and questions and answers given in connection with each chapter. It includes a large amount of matter in reference to the proper method of procedure following any conceivable accident, as well as the most satisfactory and approved method of operation under different conditions. The book can be highly recommended to anyone making a study of the locomotive, either as a student or in preparation for improved practical work.

CATALOGS.

The Machine Tool and the Motor.—The Northern Electrical Manufacturing Company, Madison, Wis., is issuing a small folder showing examples of modern practice in the application of electric motors to machine tools of different kinds.

Spring Painting.—The Joseph Dixon Crucible Company, Jersey City, N. J., is issuing a leaflet on the above subject, drawing attention to the value of graphite paint as a preservative for both metal and wood. This paint can be obtained in several different colors.

Electrical Apparatus.—The General Electric Company is issuing Bulletins Nos. 4,496 and 4,393C, the former on electric pumping plants and the latter on moderate speed engine driven revolving field alternators. The same company is also issuing a very attractive catalog on the subject of fan motors. It covers this type of apparatus very completely, showing several new arrangements.

Book Catalog.—The Hill Publishing Company, 505 Pearl street, New York, announces that the book departments of the *Engineering and Mining Journal, Power* and the *American Machinist* have been consolidated and the business will hereafter be transacted under the name of the Hill Publishing Company, Book Department. A catalog is being issued of a large number of books which it is now prepared to furnish on short notice. This covers works on mechanical, mining, and electrical engineering and allied subjects.

Electric Generating Sets.—By the issue of bulletin No. 143 entitled "Generating sets with horizontal engines," the B. F. Sturtevant Company, Hyde Park, Mass., completes its group of publications in its engineering series relating to engines and generating sets. These now comprise one bulletin each covering the following subjects: vertical enclosed engines, horizontal center crank engines, vertical compound enclosed engines, and one bulletin each descriptive of generating sets equipped respectively with each of the above types of engines.

Conveying Machinery.—The Jeffrey Manufacturing Company, Columbus, Ohio, is issuing an illustrated supplement of the Jeffrey Conveying Machinery for saw mills, lumber mills and wood-working industries. This shows chain and wire rope conveyors for timbers of all shapes and sizes, as well as wood refuse varying from sawdust to slabs. Package conveyors for handling material of almost any nature, in several different designs, are also shown in the same catalog. The illustrations show many interesting adaptations of this equipment in operation.

Centrifugal Pumps.—R. D. Woods & Company, Philadelphia, is issuing a catalog which illustrates and describes many different designs of centrifugal pumps for water works and high pressure fire service. This type of pump is becoming very popular for many services which have been previously considered as suitable only for reciprocating pumps. This company has given the subject much careful attention and study and is prepared to build centrifugal pumps of practically any size for any purpose to which they are suited. The catalog shows pumps both vertical and horizontal, direct connected or belted to electric motors, steam or gas engines. A practical and economical plant can be obtained with a gas engine using gas from a producer, all of which equipment can be furnished by this company. A recent test of a producer plant of this type showed that it was possible to obtain 20 h. p. for one cent per hour. The catalog contains many interesting figures, which have been obtained by tests of gas engine and other types of pumping plants. Brief descriptions are given of the high pressure fire service plants of several of the larger cities, in which multiple-stage centrifugal pumps are employed.

Mogul Type Freight Locomotives.—A pamphlet recently issued by the American Locomotive Company, is the seventh of the series which is being published by this company to include the various standard types of locomotives. As the title indicates, this pamphlet is devoted to the mogul type of locomotive, and illustrates and describes twenty-five different designs of this type built for various railroads. The designs illustrated range in weights from 49,000 to 187,000 pounds, with hauling capacities adapted to a variety of road and service conditions, and the pamphlet as a whole constitutes a very complete record of the production of the company in this type of locomotive.

NOTES

Morgan Engineering Company.—The above company, the main office of which is at Alliance, Ohio, announces that it has opened an eastern office at 111 Broadway, New York, of which Mr. E. J. Parker is manager.

Standard Coupler Company.—The above company announces the removal of its general offices from 160 Broadway to the sixteenth floor of the United States Express Building, Trinity Place and Rector street, New York City.

American Steam Gauge & Valve Manufacturing Company.—Mr. Gardner Cornett, of Providence, R. I., has recently been elected vice-president of the above company, his office being located at the headquarters of the company, No. 220 Camden street, Boston.

Crocker-Wheeler Company.—This company has recently been obliged to establish an office at Birmingham, Ala., which is located in the Woodward Building, and will be in charge of Mr. B. A. Schroder, who heretofore has been in charge of the New Orleans territory.

French Representative at the Foundrymen's Exhibition.—It is announced that M. Ronceray will represent Ph. Bonvillain & E. Ronceray, machine tool importers and manufacturers of moulding machines, at the American Foundrymen's Association exhibition to be held in Philadelphia, May 20 to 24. Following the exhibition he will visit the principal machine tool manufacturers for the purpose of making arrangements to handle a line of machines in Europe.

Joseph Dixon Crucible Company.—At the annual meeting of the stockholders of the company the old board of directors were unanimously reelected. At the meeting of this board of directors the former officers were re-elected as follows: Mr. E. F. C. Young, president; Mr. John A. Walker, vice-president and treasurer, and Mr. George E. Long, secretary. Judge J. D. Bedle was also re-elected as counsel. There were 6,460 shares, out of a total of 7,345 shares, represented at the meeting.

Niles-Bement-Pond Co.—On May 1 the Chicago branch of the above company will move to its new offices on the sixth floor of the new Commercial National Bank Building, at the corner of Clark and Adams streets. The Pratt & Whitney Company will abandon its present show room and offices and will combine its machinery sales department with that of the Niles-Bement-Pond Company. The show room and stock of the Pratt & Whitney Company will be located on the ground floor of the new Plamondon Building, corner of Clinton and Monroe streets.

Cincinnati Planer Company.—This company has now broken ground for its new plant at Oakley, Ohio, a suburb of Cincinnati, where an eight acre tract of ground has been secured. The present plans include the building of two buildings of modern construction, measuring 140 by 200 feet each, on completion of which the company will move to its new location. Several other well known manufacturers, including the Cincinnati Milling Machine Company, the Bickford Drill & Tool Company and the Triumph Electric Company are also locating in the same vicinity. A central power station owned by these four concerns will furnish heat, light and power for all of the plants.

American Locomotive Company's Exhibit at Jamestown.—The American Locomotive Co.'s exhibit at the coming Jamestown Exhibition will occupy a plot of 100 by 250 feet in the southern portion of the grounds on the southeasterly side of Lee's Parade grounds. The exhibit will be housed in a building especially constructed for the purpose, 177 feet long and 20 feet wide, with the entrance facing the parade. The exhibit will consist of one consolidation type locomotive built for the Southern Railway with 22 by 30 inch cylinders and slide valves operated by the Walschaert valve gear; a Pacific type passenger locomotive built for the Chesapeake & Ohio Railway with 22 by 28 inch cylinders and piston valves; a 10 by 16 inch saddle tank contractor's locomotive, and a Class 44-16-2½ Atlantic steam shovel. The steam shovel will be placed outside of the building and will be in operation under its own steam.

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A RATIONAL APPRENTICE SYSTEM.

NEW YORK CENTRAL LINES.

Synopsis.

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Introductory.

A development which promises to be the most important that has ever taken place in the motive power department of our railroads, and the general principles of which are equally applicable to manufacturing and commercial organizations, is the apprentice system recently introduced upon the New York Central Lines and now being extended as rapidly as possible throughout the system. While it is too soon to judge accurately of the final results, those thus far apparent, and the very rational and practical methods which are being used, indicate that it will very materially improve the labor conditions and add greatly to the efficiency of the motive power department.

Those who are familiar with the present labor situation, the lack of skilled mechanics, the difficulty in securing foremen and the gross neglect, on most roads, of a system for recruiting good men for these positions, must realize the great need of improvement. The most forceful presentation of this subject which has ever been made, whether we consider the railroads alone or the manufacturing and commercial interests at large, was that made by Mr. G. M. Basford in an individual paper read before the Master Mechanics' Association in 1905 (AMERICAN ENGINEER, page 251, July, 1905). The necessity of installing such a system, and a general outline of a system which would produce successful results under present conditions, was clearly presented. As these suggestions have been followed quite closely in working out the details of the system on the New York Central Lines it is suggested that a study of the following article be preceded by a careful reading of Mr. Basford's paper.

Briefly the system adopted may be summed up under the following three heads:

1. It provides for the close supervision and instruction of the apprentices in the shop by an apprentice instructor.

2. A school is conducted by the company during working hours, the apprentice being paid for attendance, at which mechanical drawing is taught in a practical way.

3. A course of problems, carefully arranged to suit the needs of the apprentices, has been prepared which they are expected to work out on their own time.

While the system differs radically in many respects from anything that has been done in this country, it follows more or less closely the general principles governing the educational system of the British Admiralty, which has been in operation more than sixty years and according to Sir William H. White has produced the majority of the men who are now occuping the most prominent positions in the ship building industries of Great Britain. In an article, published in the January, 1904, issue of *Technics*, he says of it: "It has given to private shipbuilders its leaders, who have risen from the ranks, while it has produced men holding many important and influential positions in all parts of the world."

The only system that has been carried out on a large scale in this country, which at all approaches the methods used on the New York Central Lines, is the General Electric Company's apprentice school at Lynn, Mass., which was described in a paper on "A Plan to Provide for a Supply of Skilled Workmen," presented by Mr. Magnus W. Alexander at the December, 1906, meeting of the American Society of Mechanical Engineers. A special shop has been fitted up at Lynn, known as the "Apprentice Training School," and for the first 1½ or 2½ years of the four years' course the boys work in this shop under the direction of competent instructors. The production of this department is of commercial value. The latter part of the course is spent on regular work in the shops. A school is conducted during working hours at the expense of the company, each apprentice receiving six hours' instruction a week.

Under the New York Central system the boys come into contact with the actual shop conditions from the very first.

During the discussion of Mr. Alexander's paper the fact was brought out very forcibly several times that manufacturing industries are suffering greatly from the lack of suitable means for recruiting skilled labor and that unless immediate steps are taken to remedy the difficulty the commercial resources of the country will be seriously crippled. The same thing applies with equal force to the motive power departments of our railroads.

It is true that here or there a railroad or a shop has given some attention to this subject, but generally speaking it has been almost lost sight of. The old methods are not suitable for the new conditions and an adequate system cannot be installed and carried on successfully as a side issue by an officer who already has all he can do. Fortunately the formation of large railroad systems, each made up of several railroads, makes it possible to place a work of this kind in the hands of a well qualified man who can give his entire time to it and employ the necessary assistants.

The purpose of such a movement, if it is to be successful, must be in line with the suggestion intimated by the following words of Mr. G. M. Basford, used in closing the discussion of his paper before the Master Mechanics' Association two years ago: "I beg you to bear in mind the pyramid—a pyramid of the rank

and file, the rank and file of the workmen upon whose shoulders you stand. As the base is great and upright and strong morally and intellectually, so is the structure. No structure is great and permanent that is not right at the bottom." If steps are taken to furnish a good supply of skilled workmen, well equipped for service under modern shop conditions, there will be no trouble in developing men from among them for the higher positions.

In the series of articles, of which this is the first, an effort will be made to explain just what has been done in this matter on the New York Central Lines up to the present time. The articles are intended to supplement a paper to be presented before the coming meeting of the Master Mechanics' Association, by Mr. C. W. Cross, superintendent of apprentices, and Mr. W. B. Russell, assistant superintendent of apprentices, which will be reprinted in our July issue.

Introduction on the New York Central Lines.

Mr. J. F. Deems, when he became general superintendent of motive power of the New York Central Lines, had under consideration the establishment of an adequate system of apprenticeship on that system, but the apprentice department was not inaugurated until March 1, 1906. On May 7, 1906, the first apprentice class, under this new plan, was started at the West Albany shops. It was, of course, realized that while there would be some advantages which would be almost immediately apparent, the most important results would not be noticeable for a number of years, and therefore, before starting the organization, steps were taken to insure its permanency for a period of sufficient length to enable the results to be clearly demonstrated.

Former Apprentice Schools on the New York Central Lines.

Although at the inauguration of the new plan there were twelve shops on the system, each of which had from 20 to 74 apprentices, apprentice schools of some kind had been carried on previously by the local managements at only four points, Elkhart, Ind.; Jackson, Mich.; Oswego, N. Y.; and McKees Rocks, Pa.

About 35 years ago an apprentice school was started at the Elkhart shops on the Lake Shore & Michigan Southern Railway. The sessions were held in the evening and the school was intended primarily for the apprentices, although anyone in the employ of the company was eligible to membership. This school was continued with more or less success, and in 1901, under the direction of Mr. C. W. Cross, then master mechanic, attendance was made compulsory for apprentices, and what was known as the Apprentice Association was organized. This association held meetings every two weeks, at which reports were made by committees who had visited other shops, or addresses were made by persons skilled in different classes of work. While membership was not compulsory the greater number of the apprentices belonged to it and the meetings were well attended.

On July 28, 1886, evening class work for the apprentices was started at the Jackson shops of the Michigan Central Railroad. For the first few months the classes were held from 7 to 9 P. M., but this did not prove satisfactory and was changed to 5.15 to 7.15 P. M. Each class met one night a week from November 1st to April 30th. Attendance of apprentices was made compulsory.

In January, 1904, an apprentice school was organized at the Oswego shops of the New York Central under the direction of Mr. W. O. Thompson, division superintendent of motive power. This class met for two hours, directly after the whistle blew at the close of the day, one day of each week. Attendance was made compulsory for the apprentices and they were paid for their time in the class, thus making it possible to enforce a somewhat more rigid discipline.

About two years ago an evening school was organized at the McKees Rocks shops of the Pittsburgh & Lake Erie Railroad, under the direction of Mr. L. H. Turner, superintendent of motive power, and Mr. W. P. Richardson, mechanical engineer. These classes met twice a week and attendance of the apprentices was made compulsory.

Mechanical drawing was taught at these four schools, the method being the same as that ordinarily followed, including practice in lettering, geometrical exercises, projections, copying of drawings and blue prints, making drawings of locomotive parts and making tracings.

General Organization.

The apprentice department is under the direction of Mr. C. W. Cross, superintendent of apprentices, who reports directly to the general superintendent of motive power and devotes his entire time to this work. His office is at the Grand Central Station in New York. Mr. Cross gained his early experience on the Pennsylvania Lines West of Pittsburg, after which he took a position as master mechanic on the Lake Shore & Michigan Southern Railway at Elkhart, Ind. While at Elkhart he reorganized the apprentice system in the shops at that point, making it much more effective. His very extensive and successful experience as a shop manager and master mechanic, his personality which appeals to the boys, and the interest that he has always displayed in the welfare of the apprentices, makes him especially well qualified for this position.

He is assisted by Mr. W. B. Russell, who has charge of the educational features. Mr. Russell is a graduate of the Massachusetts Institute of Technology and was engaged for a number of years as an instructor at the Pratt Institute in Brooklyn, one of the most successful trade schools in this country. He has thus had exceptional opportunities for studying boys and young men of about the same type as the apprentices in railroad shops and understands thoroughly how to arrange the work to hold their interest and so they will understand how to apply what they have learned to practical purposes.

The central organization deals with the general problems affecting the apprentice work, outlines the different courses, looks after the educational work, organizes new schools and keeps in close touch with all of the schools.

At each of the larger shops are two instructors, a drawing instructor, who in most cases is the shop draftsman and who has charge of the school work, and a shop instructor, who gives his entire time to instructing the apprentices in their shop work and to seeing that they receive the proper shop experience. Both of these men report directly to the local officers of the road, who keep in close touch with the apprentice department.

Special Features of the System.

The apprentices are instructed in drawing and in shop problems by a man already in the service of the company, on the shop property, during working hours and while under pay.

They are instructed in the trade in the shop by a special instructor, who gives the whole or part of his time to this work, and who is responsible to the local shop management.

The instruction in the trade is given in the shop on the regular tools and in the regular run of shop work.

Apprentice schedules are followed, insuring a thorough training in the trade and giving the necessary variety and work.

The drawing and the problem courses are arranged to allow each apprentice to progress as rapidly as he desires, but so as to enable a single instructor to handle classes with as many as 24 students in a class.

The character of the courses is such as to fit the standards of the road, to read in the language of the shop and to suit the special conditions existing locally.

The method of instruction differs radically from the ordinary methods of teaching in the following points:

Text-books are not an essential part of the plan.

There is no sub-division into subjects.

All principles are clothed in problem form.

There is no arbitrary standard of the amount of ground to be covered.

No examinations are held.

The progress and marks of the apprentices are based on the close personal touch maintained between the instructors and the apprentices.

The apprentice work can be installed at the greater number of the shops by using talent already in the service of the company.

OCCUPATIONS OF EMPLOYES IN THE EVENING CLASSES AT THE DIFFERENT SCHOOLS.

Occupation.	West Albany.	Collinwood.	McKees Rocks	Brightwood.	Oswego.	Jackson	Elkhart.
Machinist	12	8	13	5	2	16	2
Boilermaker		5		3			
Blacksmith	1			2		2	
Foremen, Asst.	1						1
Piece Work Inspector	2						
Helper	4		2		1		4
Hostler			1				
Tinner				1			
Clerk	2	2		1	1		2*
Crane Men			2				
Painter					1		
Car Dept.					6	1	
Electrician			2	1		1	
Upholsterer				1			
Cabinet Worker				1			
Glass Stainer				1			
Wood Worker	2						
Templet Maker	1						
Cab Maker	1						
Wood Mill		1					
Moulder		1					3
Carpenter, Fdy.							1
Tank Repairer							1
Stationary Engineer			3				1
Messenger							1
Pattern Maker							1
Total	29	16	23	16	11	20	17

Grand total, 132.

* One of these clerks is from the engineering department.

Evening Classes for the Other Employes.

The men in the shops, both foremen and workmen, have evinced considerable interest in the apprentice schools, and there has been a demand for evening schools to give them the same advantages. In response to this, evening schools have been started at a number of places, including McKees Rocks, October, 1906; Elkhart, November, 1906; Jackson, November, 1906; West Albany, November, 1906; Brightwood, December, 1906; Oswego, January, 1907, and Collinwood, February, 1907. These classes are open to all of the employees. At all of the points, except Elkhart and McKees Rocks, they meet for an hour and a half or two hours directly after the shop whistle blows in the evening. At Elkhart the classes meet from 7 to 9 and at McKees Rocks from 7.30 to 9.30 P. M. The men are more regular in attendance and take a keener interest in the work when the meeting is held directly after the shop closes. In many cases the men live a considerable distance from the shop, and it would not be convenient for them to return after going home to their dinners.

The make up of these classes, as shown in the accompanying table, is very interesting and will give some idea of the extent to which this work has been carried. At several of the schools where there is a full quota of apprentices and a waiting list the boys take places as helpers until there is an opening for them in the apprentice department. These boys usually enroll in the evening classes. Boys who have finished their apprenticeship also follow up their studies in connection with the evening classes. These classes are discontinued for three or four months during the summer. The men who attend them take the same course as the apprentices, but if they desire may skip the easier portions. As a rule they prefer to take all of the work, reviewing that part with which they are familiar. They furnish all of their own material and pay the instructor (the apprentice school drawing instructor) for his time. The cost of tuition amounts to about $1.25 per month, which ordinarily includes nine lessons. The classes are held in the apprentice school room, the company furnishing this, with light and heat, free. Only the drawing work is done in class, the problems being worked outside.

These classes give the more ambitious men an opportunity for becoming more proficient and to fit themselves for better positions. They are especially valuable for foremen and assistant foremen who may desire to "brush up" their knowledge of drawing and mathematics. As a result of the classes the shop men are becoming more familiar with the company standards and are being drawn into closer touch with the shop draftsman.

General Methods.

Apprentice Courses or Schedules.—One of the first steps taken by the apprentice department was to draw up uniform apprentice regulations to be followed at all the shops, and to arrange schedules showing the amount of time to be devoted to each part of the work for each trade. These regulations and the apprentice courses will be considered in detail in other sections of these articles.

Rate of Pay.—The rate of pay for the apprentices is controlled by the management of each road.

The School.

Place.—The school room should be located near the shop buildings from which the greater number of the apprentices come, in order that as little time as possible will be lost in going to and fro, and so that the boys can conveniently drop in during the noon hour. The room should be well lighted and ventilated. Provision should be made, if possible, for sufficient blackboard space to send the entire class to the board at one time. The floor area, including the space occupied by the filing cases, racks or tables for models and the instructor's desk, should have an average of at least 25 to 30 square feet to each member of the class, and more if possible.

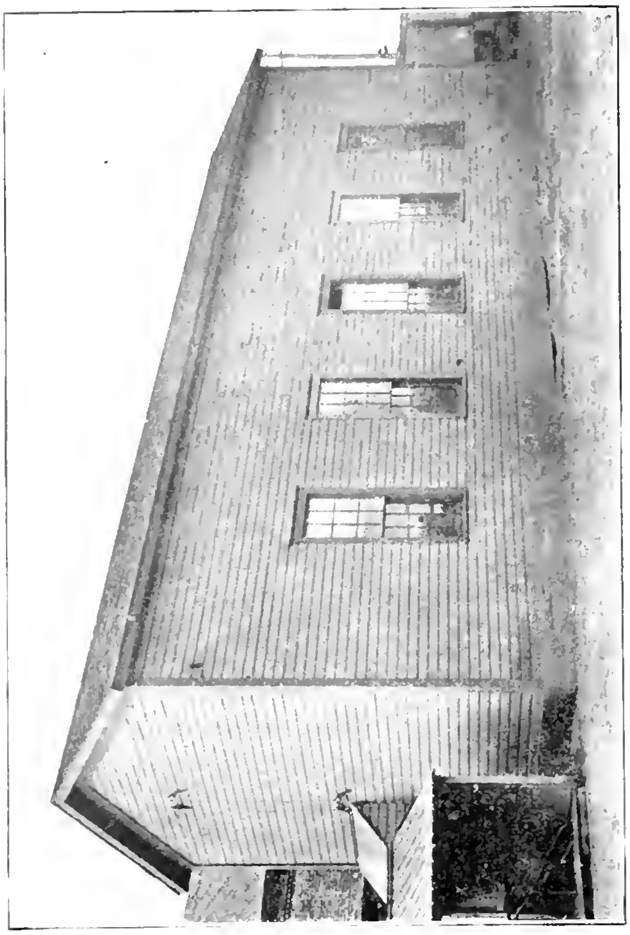
At West Albany the school is on the ground floor of a building alongside the machine shop and opposite the office building. A connecting room at one end contains the filing cases and large models. The school room is rather crowded, the drawing room tables being made specially narrow.

At Oswego, Depew, Jackson and Collinwood the school rooms are in the office buildings, the one at Depew being especially large and well lighted. At McKees Rocks a large room on the second floor of the storehouse, which is centrally located, is used. At Elkhart the school is held in a separate building, which was formerly used by one of the other departments. It is well lighted, as it is comparatively narrow and has windows on both sides.

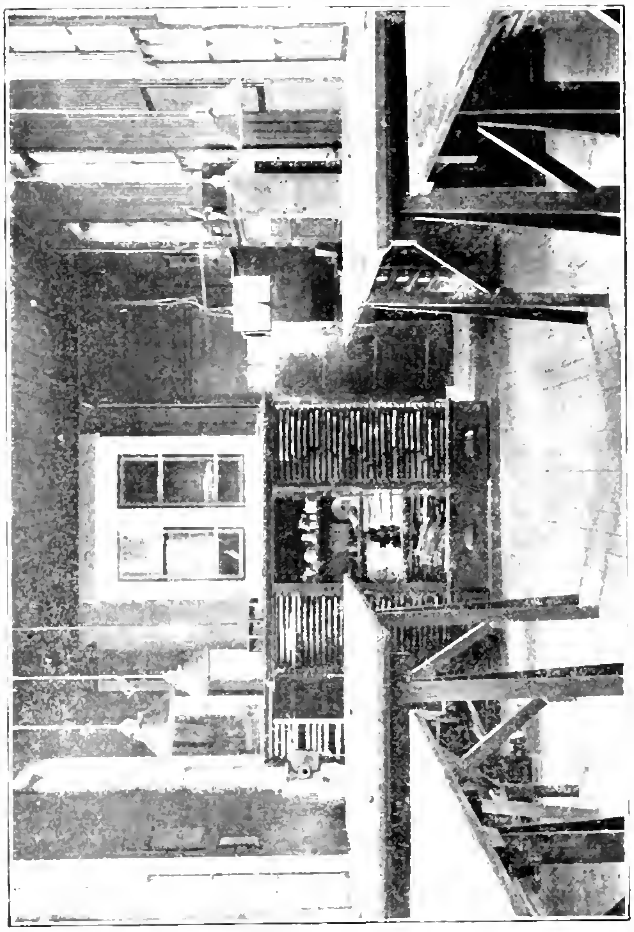
The building at Brightwood, on the Big Four, was built especially for the school. It is of frame construction, located conveniently, and the large amount of window space furnishes splendid light. Inside dimensions of the building are 25 x 50 x 13 ft. high. An idea of the arrangement of several of the school rooms and buildings may be gained from the accompanying illustrations.

Time of Meeting.—The classes meet twice a week for the first two hours in the morning. The boys are bright, fresh and clean at this time of day and able to do their best work. This is much more satisfactory than evening classes, as the boys are in a more receptive frame of mind than after a long day in the shop. The schools are closed during the month of August. The boys ring in at the shop before coming to class and at the close of the session proceed directly to the shop. Strict discipline is enforced in the school.

Grading the Classes.—No attempt has been made to grade the classes, according to the progress made by the students, except at Oswego. At that place conditions at present are such that this



APPRENTICE SCHOOL BUILDING AT ELKHART (L. S. & M. S. RY.).



INTERIOR OF APPRENTICE SCHOOL AT ELKHART.

APPRENTICE SCHOOL BUILDING AT BRIGHTWOOD (BIG FOUR).

INTERIOR OF APPRENTICE SCHOOL AT BRIGHTWOOD.

APPRENTICES IN THE DIFFERENT TRADES AT THE VARIOUS SCHOOLS.

Trade.	West Albany.	Jackson.	Depew.	Collinwood.	McKees Rocks.	East Buffalo.	Brightwood.	Elkhart.	Oswego.
Machinist	54	30	53	34	31		26	35	16
Machinist, R. H.				5					
Boilermaker	11	9	15	5	1		6	12	1
Blacksmith	1		7			1*	2		1
Tin and Copper Shop	1*	4		1	1	1*	5	1	
Pattern Maker		1					2	3	
Moulder				6				3	
Car Dept.									3
Machinist*	1*					2*			
Cabinet Maker	1*								
Carpenter						1*			
Laborers						13†			
Total	69	44	75	51	33	18	44	54	21

* Car Department.
† The 13 laborers are included in the class for reasons which will be considered in the section on "The Car Department."
The above information is correct to May 1. Since that time a number of apprentices have been added at different points.

can be done. Care is exercised that too many boys are not taken from any one department in the shop at the same time, so as not to interfere too seriously with the shop work. The drawing course is arranged so that one instructor can look after as many as 24 boys at a time, although smaller classes may be handled to better advantage. The average number of students in a class is about 17.

The Drawing Courses.—The class work is largely mechanical drawing, although some time is devoted to blackboard exercises in connection with the problem course, and occasionally the instructor may find it advisable to talk to the class about the work in the drawing or problem courses. The students are also instructed from models as to shop practice and taught the principles of the steam engine and valve setting with the aid of a small stationary engine in the class room.

The drawing course is very different from that ordinarily followed, and is based on strictly practical and common-sense lines. No time is wasted on geometrical exercises, but from the very first the student draws objects with which he is familiar and comes in contact in the shop. The first exercises are largely redrawing correctly sketches which are not in scale, the dimensions in all cases being taken from the model. New principles are introduced gradually and progress is slow but very thorough. The courses in drawing will be considered in detail in a later section of this article.

Problem Courses.—Like the drawing course the problem course is eminently practical and is based on shop practice and company standards. No matter how simple the problems, even in simple addition and subtraction, they refer to something with which the boy is familiar in connection with his work. The problems gradually grow more difficult, taking up the simpler principles of algebra, geometry, physics, elementary mechanics, etc., but these are introduced only when necessary to solve some practical problem and are not classified as such. The boys do the greater part of the problem work at home.

Text-Books.—It is not possible to use text-books in connection with either of the above courses. The work must be arranged to suit the special conditions met with in a railroad shop, and to be effective the problems must be tied up closely to the shop work. For instance, the drawing and problem courses for the locomotive and car department are not alike. The drawing problems are arranged on blue print sheets and when a boy is ready a problem sheet and a model are handed to him, the sheet giving the directions as to what is to be done. In this way each boy in the class can work on a different problem, and yet the work of the instructor is very little more difficult than if all were on the same problem.

The problems are arranged on sheets, and as soon as a boy finishes one sheet he is given another. The instructors keep in close touch with the central organization and co-operate in getting together material for the drawing and problem courses.

The methods followed in arranging these two courses are very different from those usually advocated by educators. They, however, form the real foundation of successful school work, and the rapid progress made by the apprentice schools is due largely to them. Their importance is such that we shall present a detail study of both these courses in the third article of the series.

Present Extent.

Thus far apprentice schools have been established at nine points on the system, including West Albany, Depew, East Buffalo and Oswego, on the New York Central; Elkhart and Collinwood on the Lake Shore; Brightwood on the Big Four; Jackson on the Michigan Central, and McKees Rocks on the Pittsburgh & Lake Erie. The date on which each of these schools was inaugurated, the number of apprentices in each trade, and the names of the drawing and shop instructors are shown on the accompanying tables. The boys are divided into three classes at all the shops, except Oswego and East Buffalo, these two places having two classes each. The schools were all started in 1906.

Shop.	Date School Started.	Drawing Instructor.	Shop Instructor.
West Albany	5/7	A. L. Devine	Frank Nelson
Jackson	5/15	C. P. Wilkinson	C. T. Phelan
Depew	5/28	G. Kuch, Sr.	P. P. Foller
Collinwood	6/4	R. M. Brown	Thos. Fleming
McKees Rocks	7/11	Henry Gardner	J. R. Radcliffe
East Buffalo	8/2	F. Deyot, Jr.	....
Brightwood	8/8	C. M. Davis	A. W. Martin
Elkhart	9/11	C. A. Towsley	J. S. Lauby
Oswego	11/27	H. S. Rauch	....

The total number of apprentices enrolled in the schools at the present time is 396. The total number of apprentices on the New York Central Lines, not including the Boston & Albany, is 667, so that at present more than 58 per cent. of them have the advantages of the apprentice schools. The schools are being extended to the larger shops as rapidly as possible. The larger shops where schools have not yet been established are:

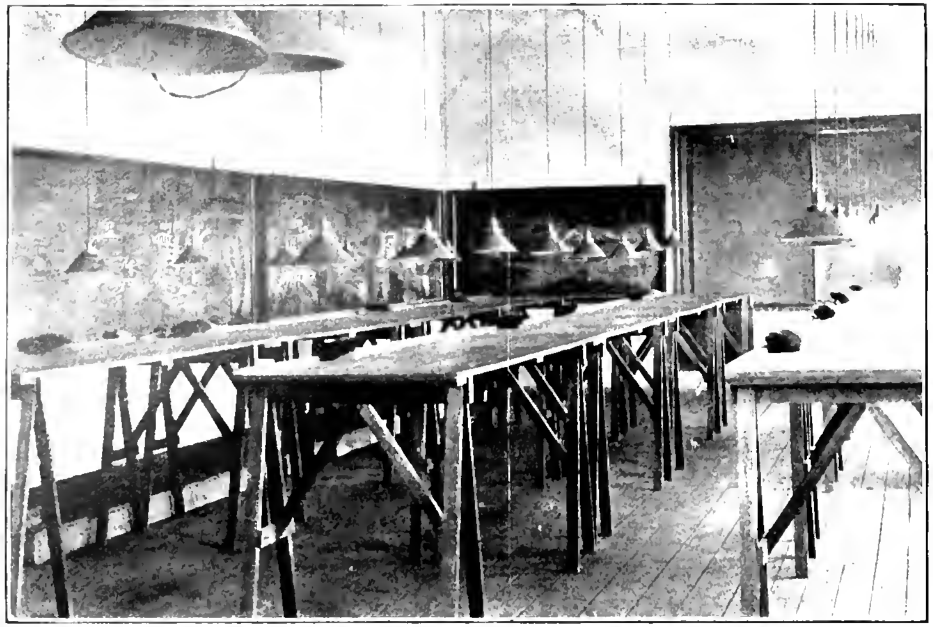
Road	Place.	No. of Apprentices.
N. Y. C.	Avis	20
L. S. & M. S.	Lima	18
L. S. & M. S.	Kankakee	12
Big-Four	Bellefontaine	36
Big-Four	Delaware	18
Big-Four	Mattoon	26
Big-Four	Mt. Carmel	14
Big-Four	Wabash	14
Big-Four	Urbana	24
Big-Four	Van Wert	15
Michigan Central	St. Thomas	27
Total		224

When schools are installed at these places over 92 per cent. of the apprentices on the New York Central Lines will have school privileges. The remaining 8 per cent. are at 13 points, each place having from one to nine apprentices. Just how these will be reached has not yet been decided, but probably by traveling instructors.

Drawing Instructor.

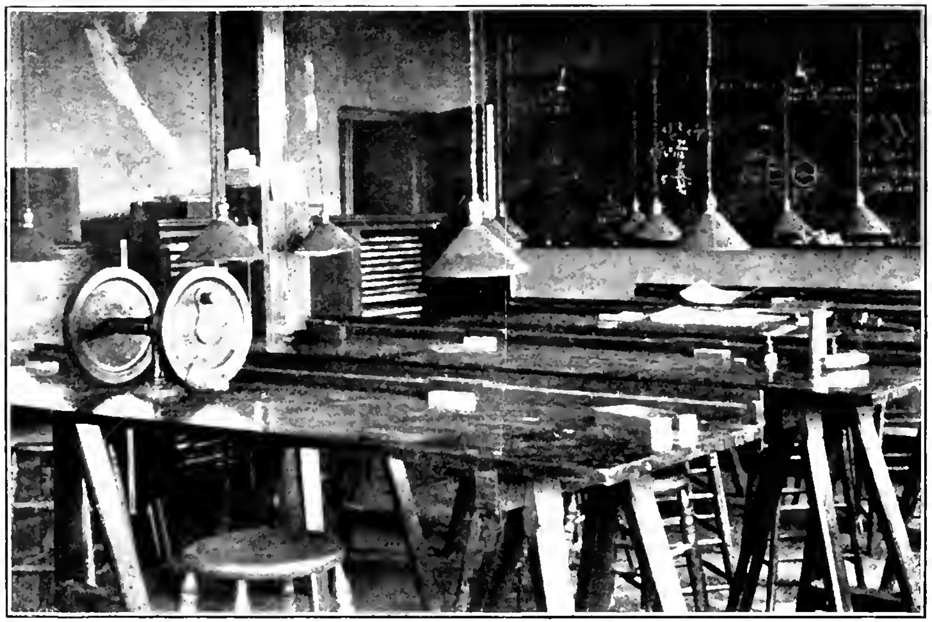
Duties.—The drawing instructor is usually the shop draftsman and reports to the shop management on all matters concerning the apprentice schools, except those which are purely educational. All reports are transmitted to the central apprentice organization through the local management. The instructor is expected to keep in close personal touch with each apprentice, so much so that it will be unnecessary to give examinations to determine the student's standing. He has charge of the school and checks up and assists the boys in connection with the problem course.

As it is necessary for him to be at the school before seven o'clock in the morning and he must also devote more or less of

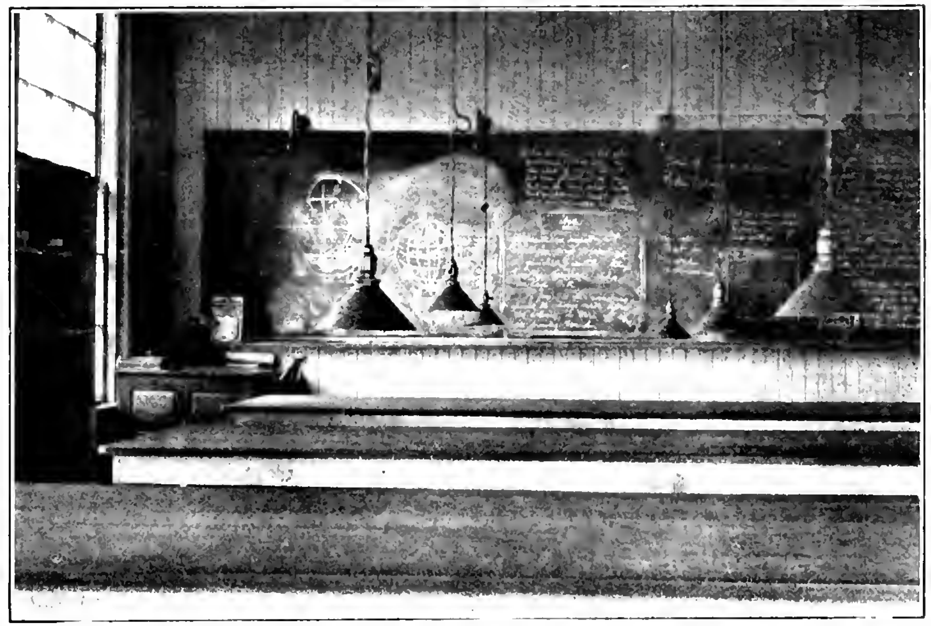


DEPEW, N. Y., NEW YORK CENTRAL.

WEST ALBANY, N. Y., NEW YORK CENTRAL.



JACKSON, MICH., MICHIGAN CENTRAL.



MCKEES ROCKS, PA., PITTSBURGH & LAKE ERIE.

INTERIOR VIEWS OF SEVERAL APPRENTICE SCHOOLS.

SCHOOL IN SESSION AT THE COLLINWOOD SHOPS, LAKE SHORE & MICHIGAN SOUTHERN.

his own time in correcting the problems which are handed in and in other duties connected with the school, he is paid extra for this service, depending on how many classes he has each week. The instructor should be at the drawing-room for at least a part of the noon hour to advise and assist any of the boys who may drop in at that time.

Qualifications.—The success of the system depends very largely upon selecting the proper men for instructors. The drawing instructor should preferably be the shop draftsman, thus being brought into close contact with shop problems and also with the men in the shop. He must be a man who will take a genuine interest in the boys and can see things from their point of view; a man that the boys will feel free to approach either for information as to their class or problem work, or for advice as to personal matters.

He should be a man to whom the boys will look for advice and assistance in forming apprentice clubs or organizations, whether intended for educational or social purposes. One instructor who is especially close to the boys is very often accosted on the street in the evening by boys who have questions to ask in connection with some problem. Some of the instructors make a practice of calling upon the boys at their homes when they have been absent from the shop due to illness or other causes. A quiet talk with a careless or indifferent boy often accomplishes remarkable results.

Observation Visits to Others Schools.—It is the policy to have the instructors visit the other schools on the system in order to broaden out and see what the other fellows are doing. A very noticeable feature at most of the schools is that upon examining the methods and equipment closely the instructor is quite likely to tell you that he got a certain idea from one point, another from still another school, etc. Possibly this feature is to some extent responsible for the rapid progress which has been made at some of the schools, at any rate it is apparently productive of important results, especially at this time when the work is just getting well started. A periodical meeting of the instructors would doubtless be productive of good results.

Understudy.—The drawing instructor should have some one trained to take his place when he is absent. His duties in connection with other work may take him away from the shop for a day or two; he may be taken ill, or find it advisable to visit one of the other schools. In such cases his assistant in the drawing room, if he has one, or one of the advanced apprentices should be in position to look after the school. At Brightwood the drawing instructor was ill for some time and his place was filled by the shop instructor.

Shop Instructor.

The shop instructor is an important factor in the organization. The Collinwood shop on the Lake Shore was the first to introduce an apprentice shop instructor, and the results were so immediately apparent and important that this feature was included in the new apprentice organization when it was started.

Duties.—The shop instructor at the larger shops gives his entire time to looking after the apprentices. He instructs the boys at their trade and sees that they are changed from one class of work to another, in accordance with the apprentice schedules. In changing the apprentices about the instructor consults with the various foremen, studying the situation carefully in order to have as little friction as possible in making the changes, and so as not to interfere too greatly with the efficiency of any one department. His suggestions must of course be approved by the shop superintendent before being put into effect.

He must pass upon all applicants for apprenticeship as the official representative of the apprentice department, and is also to make recommendations as to apprentices who are unsatisfactory and should be dropped from the service; in fact, he is held responsible for the retention in service of apprentices who are incompetent or otherwise unsatisfactory. He is expected to assist and consult with the drawing instructor as far as possible.

The apprentices report to their foremen, as before, but the foremen are relieved of all responsibility of instructing them. Ordinarily very great returns are not to be expected from the introduction of an apprentice system until after a period of several years, but the work of the shop instructor has been found to almost immediately affect the shop output, and this is to be expected. The shop foremen are too busy to spend much time with the boys, and ordinarily the instruction in shop practice has been very much neglected, thus restricting the output and increasing the amount of spoiled work. The shop instructor is expected to occasionally visit other shop schools to study their methods.

Qualifications.—The shop instructor, like the drawing instructor, must have a great deal of patience with, and take a genuine interest in, the boys. He must be a good mechanic, must have sufficient all-around knowledge to enable him to look after the boys in the various trades, and his position in the shop organization should be such that the boys will look up to him. Most of all, he should be a man who will appeal to the boys and know how to convey his ideas so that they will readily understand him. He should take a broad view of the shop problems, giving the boys some idea as to the general principles affecting their work, such, for instance, as movement of material through the shop, the cost of production and the elimination of lost motion in performing their work.

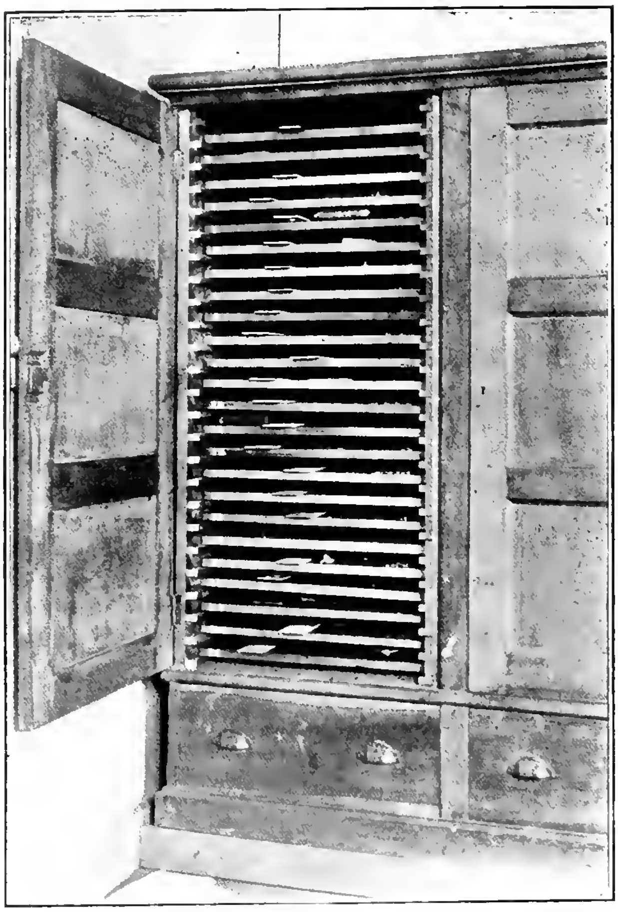
Advantages to the Instructors.

In addition to what financial compensation the drawing and shop instructors receive there are other important advantages. To successfully handle their work they must study up and become more familiar with the work in the various departments of the shops. They become familiar with shop practice at other

points on the system by occasional visits. If they have marked executive ability it soon becomes apparent, and this with the broader view they have of the shop operation fits them for more important positions in the organization. Nothing is quite so important in crystallizing one's ideas and broadening a man as trying to instruct others.

Facilities and Equipment.

Drawing Room Equipment.—An effort has been made to provide sufficient blackboard space in each school room so that the entire class, if possible, may be sent to the board at one time. A standard drawing table is used at several shops, but at others the shape of the room, or equipment already at hand, made it advisable to deviate from this. The construction of this table is shown in the accompanying drawing. It is simple but substantial and inexpensive. Drawing stools are furnished and are especially appreciated by the evening classes.



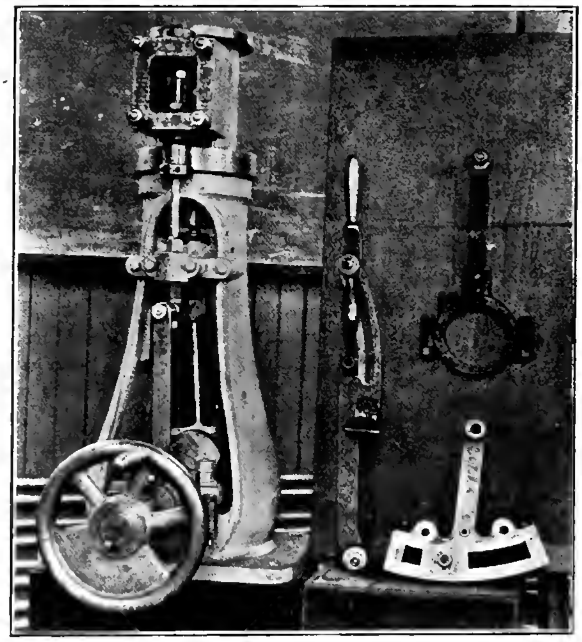
SECTION OF THE CASE FOR FILING DRAWING BOARDS AND TOOLS.

Cases are provided for filing the drawing boards and tools. A section of one of these standard cases is shown in the accompanying photograph. Each drawing board is numbered and is filed in a corresponding space in the case, the tools being placed in an orderly arrangement on top of the board. These cases are made of $\frac{7}{8}$-in. pine with an oak stain finish The section for filing the drawing boards is $19\frac{1}{4}$-in. wide, $27\frac{1}{4}$-in. deep and 3-ft. 6-in. high, this being sufficient for 24 boards. The drawers at the bottom are used for storing material. Racks or tables are provided for the drawing models. The arrangement used at Depew is shown in one of the photographs. Cases of various kinds are used for filing the finished drawings, the problem sheets and the solutions which have been handed in. The drawings and solutions to the problems are kept by the instructor and returned to the apprentices in lots of fifty.

Equipment Furnished to Each Boy.—Each boy is furnished with a pine drawing board, shellac finish, 18 x 24 x 11/16 in. thick. These boards have $\frac{1}{4}$ x 1 in hardwood strips mortised in each end to keep them from warping. In addition, the boy is furnished with a T square, celluloid triangle, a wooden curve, triangular box scale, thumb tacks, erasers, erasing shield, protractor, pencils, a file for sharpening the pencils, ink, pens and pen-holder and the necessary drawing and tracing paper. This equipment is shown in one of the illustrations. As these supplies are purchased in large quantities the cost to the company is comparatively small.

Drawing Instruments.—The boys are expected to provide their own drawing instruments, which because of the large number of sets required are comparatively inexpensive. A splendid set may be secured for $4.00, and very satisfactory sets can be obtained as low as $2.50.

Models.—The drawings are all made either from the actual parts or from wooden models, which are easier to handle. Each school is arranging to secure a small vertical engine and a light engine lathe, not necessarily new or up to date, which will be used in connection with the drawing and problem courses. Any number of practical problems may be based on the gearing, pulleys, etc., of the lathe and the principles of steam distribution and valve setting may be taught in connection with the engine. Models of the Walschaert valve gear are also being provided.



VERTICAL ENGINE ARRANGED FOR DEMONSTRATION PURPOSES AT THE ELKHART SCHOOL.

At Jackson, Mr. Phelan, the shop instructor, has some wooden models for instructing the boys in quartering driving wheels, etc. These are shown in the photograph of the school room at Jackson. At McKees Rocks, Mr. Radcliffe has constructed a model of the foundation brake gear used in connection with a four-wheel truck with inside hung brakes.

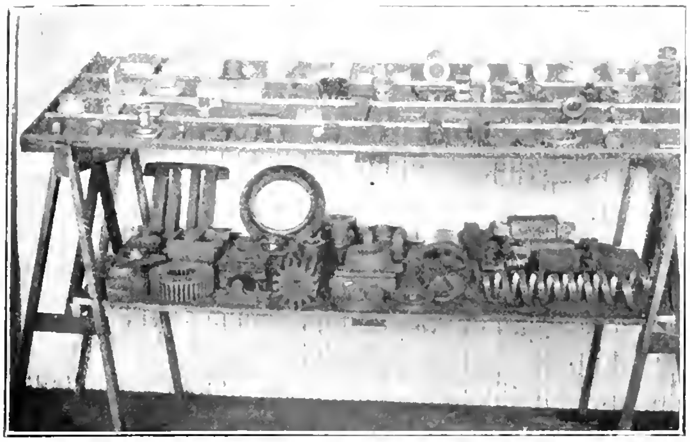
Reference Books.—No text-books are used, but each boy is furnished for reference with a copy of "Machine Shop Arithmetic," compiled by Fred H. Colvin and Walter E. Cheney, and "Link Motion," by Fred H. Colvin, both of these books being published by the Derry-Collard Company, of New York. The boys at one or two of the schools were furnished by the Morse Twist Drill & Machine Company with a small pamphlet known as the "Young Machinist's Practical Guide." It is planned to have other technical books and trade papers kept on file for reference at the different schools.

Charts.—At West Albany a series of charts have been furnished by one of the air brake companies, showing the different parts of their apparatus. Charts have also been furnished by a steam gauge company, showing the construction of its gauges.

Trade Catalogs.—Catalogs of interest to the students are kept on file at each school. In several instances catalogs or publications of special interest have been furnished to each apprentice, such for instance, as a publication on the cross-compound locomotive, published by the American Locomotive Company, and given to the apprentices of the Michigan Central, where this type of locomotive is used very largely. The Allfree-Hubbell catalog

was furnished to each apprentice on the Pittsburgh & Lake Erie where a number of these engines are in service.

Stereopticon and Reflection Lantern.—A combination stereopticon and reflection or opaque projection lantern has been purchased by the railroad company and will be used in connection with any lectures that may be given. The lantern was purchased



RACK FOR MODELS AT DEPEW.

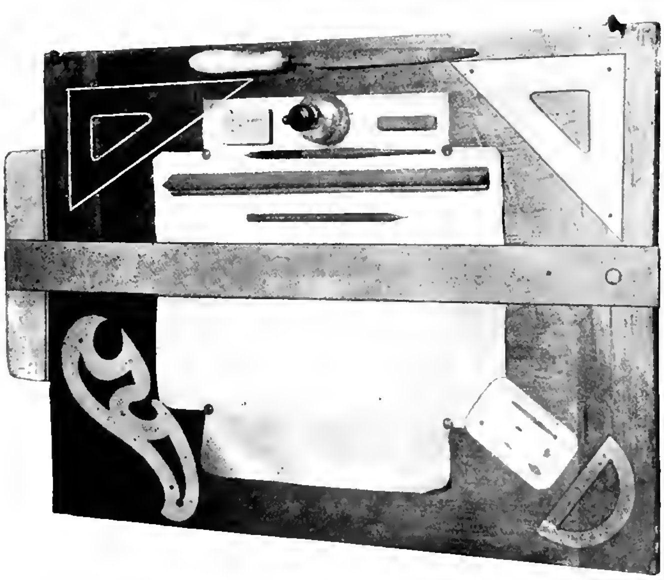
from the L. E. Knott Apparatus Company, of Boston, Mass., and in addition to using the transparent slides can be used to reflect on the curtain views of printed matter, drawings, photographs or any opaque substance.

Air Brake Instruction Car.—These cars can doubtless be used to good advantage by having them devote a part of their time to the shop apprentices; in fact, this is being done on one or two of the roads.

Other Facilities.—The testing laboratories, machinery and equipment, especially at the larger shops, afford exceptional opportunities for occasional practical demonstrations in connection with the class work.

Interest Shown by the Boys.

The apprentices generally have displayed considerable interest in the work of the school and the efforts which are being made to improve their opportunities. This is clearly shown in a number of ways, and especially by the earnestness with which the greater number of them are following up the drawing and problem courses. At several shops the writer managed to drop in at the school during the noon hour, after the boys had eaten their lunch, and almost invariably several of them would be found



MECHANICAL DRAWING EQUIPMENT FURNISHED TO EACH APPRENTICE.

working on problems, looking up references, asking questions of the instructor, or talking the work over among themselves.

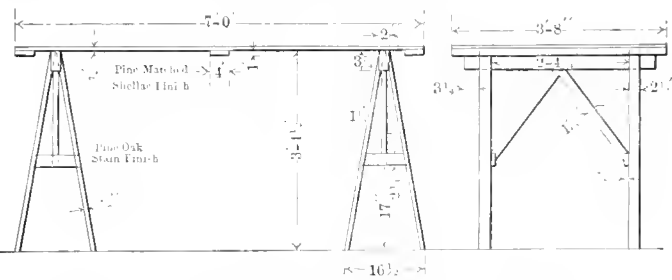
Some of the boys have completed their apprentice course since the school was inaugurated, but realizing the opportunity which was being placed before them they have enrolled in the evening classes and are continuing their studies in that way. The drawings made by the boys are very good, both as to accuracy and neatness, considering the work in which they are engaged.

Advantages Thus Far Apparent.

Better Class of Boys Being Secured.—While only two or three of the schools have been in operation for as long as a year, a number of practical advantages have become apparent. With the greater opportunities that are being offered a better class of boys is being secured. Formerly it was difficult to keep up the full quota of apprentices at most of the shops. Now there is a waiting list for some of the trades at several shops, and apprentices are being secured for trades formerly without them. In many instances high school graduates have enrolled as apprentices. At shops where there is a waiting list it is not unusual for the boys to take places as helpers or wipers and enter the evening classes until an opening occurs in the apprentice department. This service is a sort of probation period and those who are unsatisfactory are sifted out.

Understand Instructions More Readily.—The boys take a greater interest in their work in the shop, and because of the principles learned in connection with their educational work, are better able to understand the instructions given to them and to carry them out intelligently. Their earning power is thus increased.

Greater Output.—The work of the shop instructor is especially productive of immediate returns. When the apprentice is shifted to a new class of work the instructor stays right with him until



STANDARD DRAWING TABLE FOR APPRENTICE SCHOOLS.

he understands it thoroughly. Under the old system the foreman was supposed to instruct the apprentice. He would almost invariably be interrupted a number of times and would probably hurry off after he had half instructed the boy, expecting to return shortly. The chances were that he would forget all about it and the boy would be left to shift for himself. As one shop superintendent tersely put it—under the old system a boy after working on a machine for two or three weeks might get to a point where he could produce one-half of a mechanic's output—now he can on an average turn out seven-eighths of a mechanic's output after three or four days. When a workman does not report for duty an apprentice can be put on the job under the direction of the instructor and the output does not suffer to any great extent. The increase in the apprentice's output due to the above causes more than offsets the loss of time due to class work, which amounts on an average to forty minutes a day for each boy.

Less Spoiled Work.—The amount of spoiled work has been very greatly reduced, due to the advent of the shop instructor.

Knowledge of Drawing Put to Practical Use.—The brighter boys, after they have worked for several months in the drawing course, may be used to considerable advantage for making rough sketches or simple drawings, either of a broken part, for transmission to the mechanical engineer's office, or in connection with the shop practices.

One master mechanic, in speaking of the apprentice courses, said that if on twenty-four hours' notice he was asked to establish a mechanical engineer's department with a force of six or eight draftsmen, he could do so by selecting his men from among the apprentices and would guarantee to make as good a record as the average railroad mechanical engineer's office. It is only fair to say that the apprentices at this particular shop had had the advantage of an evening school course previous to the establish-

ment of the present system, although it was not nearly as complete as the present one. The man who made the remark was in earnest and was thoroughly conversant with the work expected of a railroad mechanical engineer's office.

STEEL PASSENGER EQUIPMENT.

By Charles E. Barba and Marvin Singer.

I.

Present Status of Steel Passenger Cars.

The past few years have seen the beginning of a new industry in America, and although the construction of all-steel cars is in its infancy, it promises to effect a permanent revolution in passenger equipment. It is hence of vital importance that the question of economic car design be given careful technical consideration; technical not alone in the matter of construction and repair, but from the standpoint of transportation requirements.

It is the purpose of this series of articles to advance methods by which the fundamental laws and principles governing the action of the structural materials, under simple and combined stresses, may be applied to the design of steel passenger equipment so as to secure a maximum of strength and convenience with a minimum weight.

In this introductory article an endeavor will be made to indicate the most prominent economic and social needs and necessities which are forcing the introduction of the steel passenger car and note the various cars brought forward to solve these transportation problems of the present and immediate future.

Our lumber resources are fast approaching the stage reached in Europe years ago. The general supply of timber near the regions of greatest industrial activity has been fearfully depleted and the exhaustion of these nearby forests puts the native supply so far away as to make the transportation charges an ever-increasing burden. As a result the commodity is not at all stable. The market value of some of the ordinary varieties used in car construction and maintenance has risen over 100 per cent. in the last few years, and even at this price it is almost impossible to secure timbers of a size large enough to construct the framing of long coaches without resorting to splicing. In seeking for a material to replace wood it is necessary that it be a product of a firmly established and comparatively stable industry. Designers have turned to steel, as answering the requirements with best satisfaction, and its suitability and high efficiency clearly indicate the advisability of its general use in future car construction from an economic standpoint.

The managements of modern railroad systems have been compelled to resort to elevated and subway construction in order to relieve the congested traffic on lines of greater passenger density; the limitations under which the existing surface railways must operate, make it impossible for them to adequately satisfy the needs of travel in these districts. The general introduction of the above modes of transportation has increased the probability of fatalities, incident upon accident, to such an extent that the displacement of wood by the metals, as a constructive element in equipment for such service, is inevitably coming. The use of steel and fireproof materials will instill a feeling of security in the public and satisfy the legal demands for immunity from the greatest dangers to life and property. The substitution of steel will secure the required increase in strength at a slightly increased weight for coaches and a decreased weight for sleepers. The dead load carried per passenger will be reduced and economies in operation will result.

Probably the first definite intimation, that cars framed and finished entirely in metal would soon be introduced to a large extent, was the intention of the Pennsylvania's late president, expressed in connection with the New York tunnel projects a few years ago, that none but such cars would be used for the service and that the traffic would require 1,000 coaches and 500 Pullmans. This contemplated step occasioned much surprise at the time as the idea was much bolder than had been attempted in foreign countries where cars with steel frames had been running for years. Much doubt was expressed as to the feasibility of such an innovation. In the ranks of the car builders and the railroad world scepticism was rife as to the practicability of turning out such a car and preserving a harmonious appearance combined with great strength and low weight. Considerations of safety, especially for electric control, and economy of operation made the necessity a live issue and the patent office records of papers issued to car designers and the frequent illustrations of the practical working out of these designs in the technical journals show that no effort has been spared to solve the problem. Nearly all of these designs have points which are worthy of note, but with a few exceptions they seem to bear evidence of too low an estimate of the requirements of strength and of operating shocks and stresses, since it is evidently but a matter of a few years until we shall have compete trains of such cars in operation, including postal, baggage, dining, combination, coaches and Pullmans. While at first hesitating to make the large outlay necessary to successfully build such equipment the commercial car builders are now entering the market, and we may expect the art to progress with great bounds to such an extent that they will be unable to satisfy the demands of the railroad companies. In underground running the dangers from fire are greater than from collision, and the necessity for non-collapsible fireproof cars for such service is evident.

The necessity for cars of this kind is just as great for our long distance, high-speed service, where luxurious buffet, dining, parlor and sleeping cars have provided comforts at the expense of increased weight. To meet the requirements of these fast schedules with heavy trains the modern passenger locomotive of large tractive power has been developed. Considerations of safety demand that the passenger equipment of such a train be of a uniform strength, capable of resisting the greater shocks in service and accident due to the greatly increased kinetic energy of the moving unit.

The modern wooden coach, following the tendencies of design, as presented by Pullman practice, is a great improvement over its immediate predecessor. The early cars were built to conserve expenditure and at the same time they suitably met the traffic demands. For through service their limitations soon became apparent and the long heavy equipment took on more the character of bridge design and departed much from that "developed from wagon building and consisting of timber framing held together by nails, spikes, straps, lag screws, and bolts." (M. C. B. A.—1897.) To meet the requirements for increased length the framing became heavier and heavier, developing in the form of Howe, Pratt, Challender, and other trussed side frames and the substitution of additional sills until we now have as many as eight of them continuous over the length of the car. We have reached a point where the future development must be met by a radical departure from the present designs in order to reduce the ever increasing weight and momentum of fast express trains. Operating conditions, as prevailing at present, have forced the conclusion that further reinforcement of wooden coaches either by the addition of more and heavier timber bracing or by the use of steel is not at all profitable.

The large initial orders of the Pennsylvania, a few weeks ago, are an indication that, though the steel passenger equipment is but in the initial stage of its development, the railroad companies are taking advantage of the superiority which is possible in steel designs and depend upon such cars to satisfactorily solve the constantly increasing difficulties of the passenger traffic problem. This means that the steel railway car for such service is regarded as an accepted type of railway rolling stock, and though the initial cost may be somewhat higher, the ultimate returns will more than offset the expenditure. That the future will see few new cars constructed of wood is the opinion shared by several managements and evidenced by the hasty preparations of the car builders to be ready for the change. The introduction of this improved equipment will without doubt proceed as fast as the resources of the companies will permit.

Contrary to what one would consider a natural course of events

the Master Car Builders' Association, up to date, has given no consideration to the steel car question and made no recommendations. Since 1885 no report or paper concerning passenger car framing has appeared. Following along the lines of railroad regulation for the sake of uniformity in safety and operation the Interstate Commerce Commission had a bill introduced in the House at Washington by Congressman Esch, of Wisconsin. Though by no means the only evidence of such legislation it is the most far-reaching of any bill brought forward to aid the railroad companies in their endeavors to secure for the public the best service possible. This bill thoroughly covers specifications for the framing of the underbody and superstructure, vestibule and platform, floor and roof of passenger coach, mail, chair, smoking, combination or tourist sleeping cars and provides a date after which it shall be unlawful to construct or operate cars which do not come up to the specifications. The items of this bill would equalize the resisting qualities of all classes of cars, a result which car builders have made an effort to secure by steel reinforcements of existing cars, but which is introducing the coming advent of an all-steel equipment on an instalment plan and is at its best but a half-hearted attempt to secure a few of the advantages obtained by an all-steel construction.

The experience gained from the development of the steel freight equipment in the last decade and from the steel reinforcement of our wooden passenger equipment, in providing for increased capacity and end shocks may be used as a basis to indicate the elements underlying the design of framing for steel passenger cars along lines which are theoretically correct. Thus the structure need not be an experiment nor will it mean simply a substitution of steel for the present wooden framing. That wood and steel are of equal strengths for equal weights does not hold true when full advantage of the possibilities of distribution of the more efficient metal are taken. In this case for the same weight steel is the stronger.

When the construction has advanced further due to the character of detail design, facilitating the application of more economical production, these cars can be built for the same if not for less cost than the present wooden ones. When this stage has been reached the wooden cars now running will be superseded by equipment which will secure to the public the benefits to be derived from its increased strength and reliability.

From an inspection of the steel passenger equipment already built, we note that the designs are not at all uniform, due, no doubt, to too much personality entering into the development instead of a hearty co-operation between the railway managements and the car builders. The railroad managements cannot be too careful in considering the preliminary designs for the purpose of securing the advantages afforded by extensive interchangeability and standardization, whereby initial construction is hastened, repairs are facilitated, the necessary stock of storehouses is reduced and shop work simplified.

The ordinary passenger equipment comprises various lengths of coaches, combination, baggage, dining and mail cars for locomotives, steam and electric, and electric car operation. Unhampered by any existing designs or precedents the framing and detail construction of these cars should be made suitable for the various motive powers and interchangeable to a noteworthy degree.

Outlining, in general, a scheme of construction with this idea in view we might adopt a section between side posts, comprising two or three windows, as a unit and obtain various length cars by the addition or elimination of these units, and finish the car with a standard end, including platform and vestibules. Having such a section for baggage and mail and one for coaches, together with stub and wide vestibule ends, would mean that any car or combination of cars could be built by simply joining these various suitable units. The superstructure of these units for baggage or mail and for passenger coaches would be uniform, using the same posts and carlines; upper and lower deck roof sheets; deck plates; deck window frames applicable for trailing, pivoted and fixed sash; side eaves and letter boards; belt rails and panels beneath. Windows, window frames, window sills, window capping, and the castings can also be made the same in each section.

This same principle can be applied to the underframe by designing the sills for the maximum length car and when shortening for smaller ones, a central unit may be removed and, where advisable, the thickness of cover plates reduced. Hence the ends of the underframe are standard, one for full vestibule and one for short; here the riveting can be anything that is consistent with good design, but in the central unit section it must be a constant function of the distance between posts so that the removal of such a unit will not alter the spacing. The underframe should be built with a view to clearances required for both steam and electric service and hence designed to take either motor or trailer truck. Interchangeability may even extend as far as the fittings for the two modes of operation. These ideas will govern the future theories of design which we shall advance and full advantage will be taken of their possibilities.

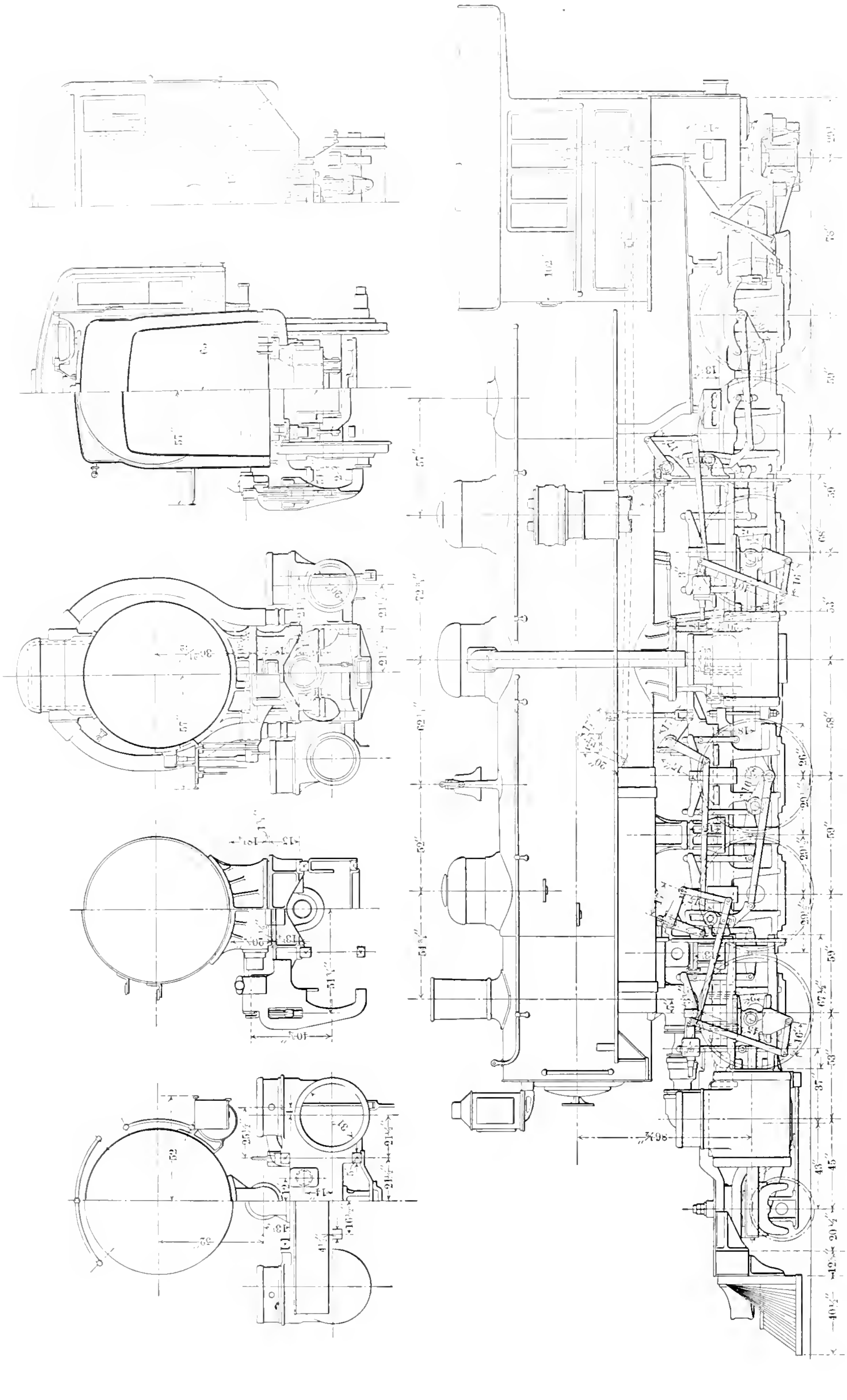
We know that it is impossible to build wooden cars as strong as steel cars of the same weight, likewise for equal strengths the wood is heavier. Hence the steel car provides a greater coefficient of safety for similar weight and an increased operating efficiency for equal strengths so that the question of steel passenger equipment is one in which the designers must bear in mind that for the greatest strength and least weight the disposition of every ounce of material placed in the framing should be such as would help to sustain its share of the strain.

Far-sighted car designers years ago recognized the value of the use of steel for such purposes. Their ideas, however, were not adopted, not from a lack of worth, but because they were years ahead of the economic needs. The transportation problem was not so complicated and dangerous and our lumber resources made it impracticable. To show the correctness of the reasoning of these early inventors and that the present designers are following the same principles, the following is quoted from the patent issued to B. J. La Mothe in 1854, this being one of the earliest examples with which we are acquainted:

"The three requirements for railroad cars are, first, lightness; second, strength; and third, slight elasticity or toughness, as distinguished from rigidity, thereby providing against accidents in cases of collision by preventing the structure from being either broken up or considerably indented or smashed, which would in either instance be nearly equally destructive to life."

"It is well known that all the weight of railroad passenger and freight cars is borne by the floors and platforms, the upper parts being of a character scarcely more than competent to sustain their own weight, and hence become principally coverings to retain and protect the contents of the car. Where these upper parts are made of wood, considerable weight is added to the car without increasing its strength to bear the load it contains, and in case of accident these brittle frames are broken into fragments and inflict more personal injury than the actual concussion consequent upon the speed of the train, hence I desire that the platform and floors of the cars (the only parts which really resist concussion) be formed very strongly and provided with competent springs at the ends, while the upper parts of the car to which my invention relates, be formed as a light, strong, permanent and elastic inclosure that will not vibrate under the motion of the train, neither will it crush down in cases of collision, but be elastic, slightly yielding to great pressure and then spring back to the proper form. At the same time the sides act to strengthen and support the platform and the load thereon."

Besides the above there are a number of other early cars which are noteworthy in that they embody the essential ideas that govern present practice. In La Mothe's design the theories concerning the underframe were sound, but he preserved wooden center and side sills while making the superstructure of metal. Five years later Mr. Joseph Davenport designed a car with both underframe and superstructure of iron. He realized the possibility of the best distribution of the metal in the framing and replaced the bar metal of La Mothe's by "U"-shaped posts and carlines connected by longitudinal braces of bar iron, using eaves and side sills of angle iron and pressed or rolled intermediate cross bearers similar to the posts; though the construction of the center sills is faulty the design presents many good ideas.



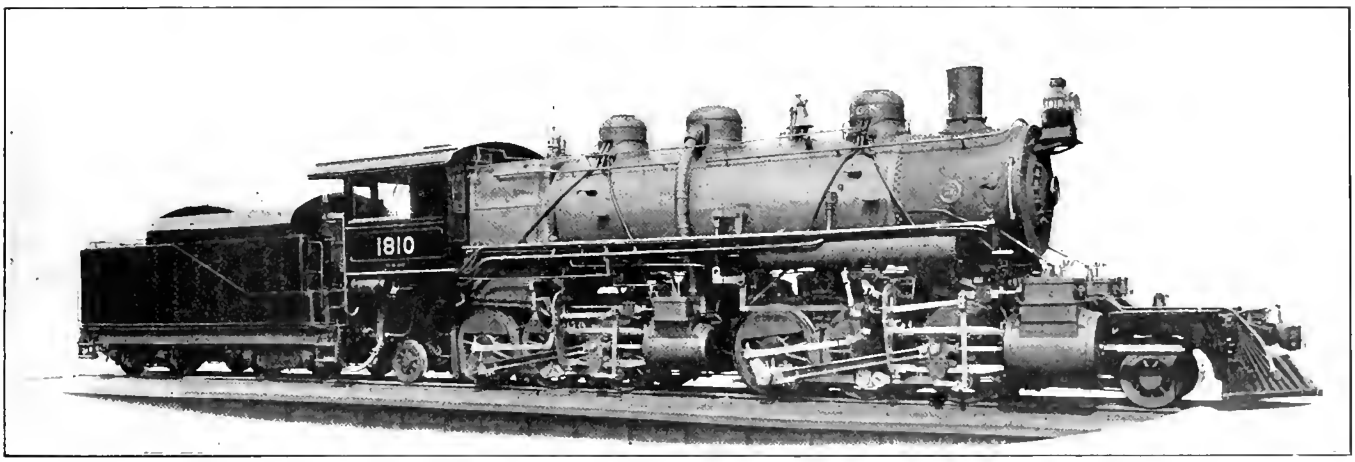
2-6-6-2 TYPE MALLET COMPOUND LOCOMOTIVE FOR REGULAR FREIGHT SERVICE, GREAT NORTHERN RAILWAY.

In 1860 Mr. Robert Montgomery offered a design which was an advance over Davenport's in the character of pressed framing. Here we first note the use of corrugated iron to support the floor. Interior steel sheathing is to be noted in a design by Mr. John A. Roebling later on in the same year. These early cars possessed in common the feature of center sills continuous over the platform. The next thirty years saw these same ideas worked out by numerous designers in various ways and also brought to light some cars of a peculiar character, such as one framed entirely of steel tubing with the center bearing fastened directly to the center sill, and another formed as a large shell of annular steel rings with the windows set into the sides. Mr. Edward Meatyard advanced the idea of continuous posts and carlines, with side sills of channel iron and center sills of "I" beams. Especially notable is the design of his all-steel truck.

During this period the clerestory, metallic window frame and window sash were introduced. Structural and pressed steel also began to gain prominence in the design. From 1890 until 1902 or 1903 the art progressed to a marked extent in the manner of mechanically solving the problem, but the matter was only in a formative state and it is believed that the introduction of the steel side door suburban car on the Illinois Central (AMERICAN ENGINEER, October, 1903, page 358) in the fall of 1902 marked the beginning of the new industry in America. A few months later the car for the Interborough Rapid Transit Company (AMERICAN ENGINEER, October, 1904, page 375) of New York was placed in service. It was a step farther toward entire steel construction than the Illinois Central car. Since that time the designs tabulated have been built.

Name of Road.	Class.	Builder.	Reference in this Journal.
Long Island	Motor Passenger	American Car & Foundry Co.	September, 1906, page 340
Long Island	Passenger	" " " "	February, 1907, page 49.
New York Central	Passenger	" " " "	March, 1907, page 81
Santa Fe	Postal	" " " "	October, 1906, page 397
Erie	Baggage and Mail	Standard Steel Car Co.	....
N. Y., N. H. & H.	Postal	" " " "	....
Southern	Passenger	Pressed Steel Car Co.	July, 1906, page 260
Pennsylvania	Passenger, 58 ft.	Pennsylvania Shops	....
Pennsylvania	Baggage	" "	....
Pennsylvania	Postal	" "	April, 1907, page 136
Pennsylvania	Passenger, 70 ft.	" "	June, 1907
Pennsylvania	Diner, 70 ft.	" "	....
Pullman Company	Sleeper	Pullman Car Co.	April, 1907, page 130
Southern Pacific	Passenger	Southern Pacific Shops	January, 1907, page 6

These cars present more or less valuable applications of the three fundamental theories of underframe design to take care of the static and service stresses to which a car is subjected. We have never seen in print a consideration of the best methods to be pursued in determining the stresses involved in the framing due to combined end shocks, dead or live weights and the most economical and practical distribution of the material to secure the maximum strength. The following article will deal with the problem as affecting the underframe.



MALLET COMPOUND LOCOMOTIVE FOR REGULAR FREIGHT SERVICE—GREAT NORTHERN RAILWAY.

MALLET COMPOUND FREIGHT LOCOMOTIVE.

GREAT NORTHERN RAILWAY.

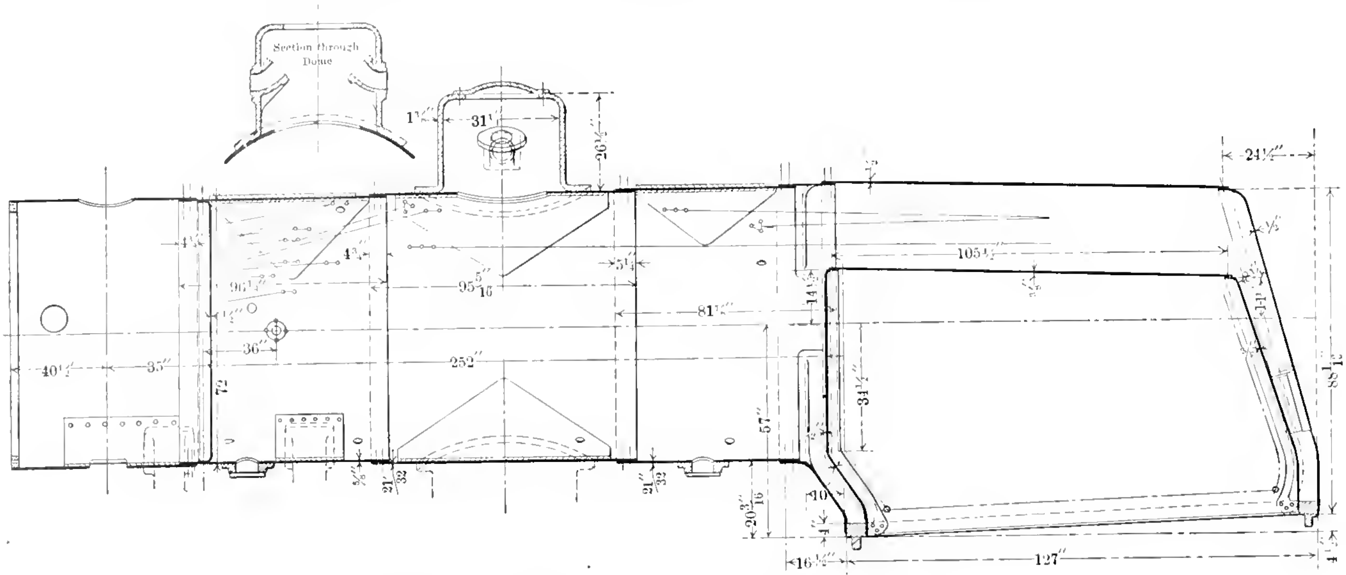
The Baldwin Locomotive Works is delivering an order of twenty-five Mallet compound locomotives to the Great Northern Railway which are of special interest as being the first of this type to be put into regular road service in this country. It will be remembered that this railroad received five locomotives of the same type from the Baldwin Works last fall,* which were designed for pusher service in the mountains and have been giving most satisfactory results in that capacity.

This later order being designed for different service, naturally differs from those now in use in many respects. They are lighter in weight, have smaller cylinders, a much smaller boiler and a somewhat shorter wheel base. In the general features and arrangement of parts, however, the two designs are very much alike. The accompanying table will show wherein the principal differences lie. It will be noticed that the boiler is very decidedly smaller, having but 3,906 sq. ft. of heating surface, while the pusher engines have 5,658 sq. ft. This, however, does not necessarily indicate that the freight engines have too small a boiler capacity, as the ratio of 229 sq. ft. of heating surface to 1 cu. ft. of cylinder volume shows them to be well within the usual range in this respect, but it does show very clearly that they are intended for an entirely different kind of work.

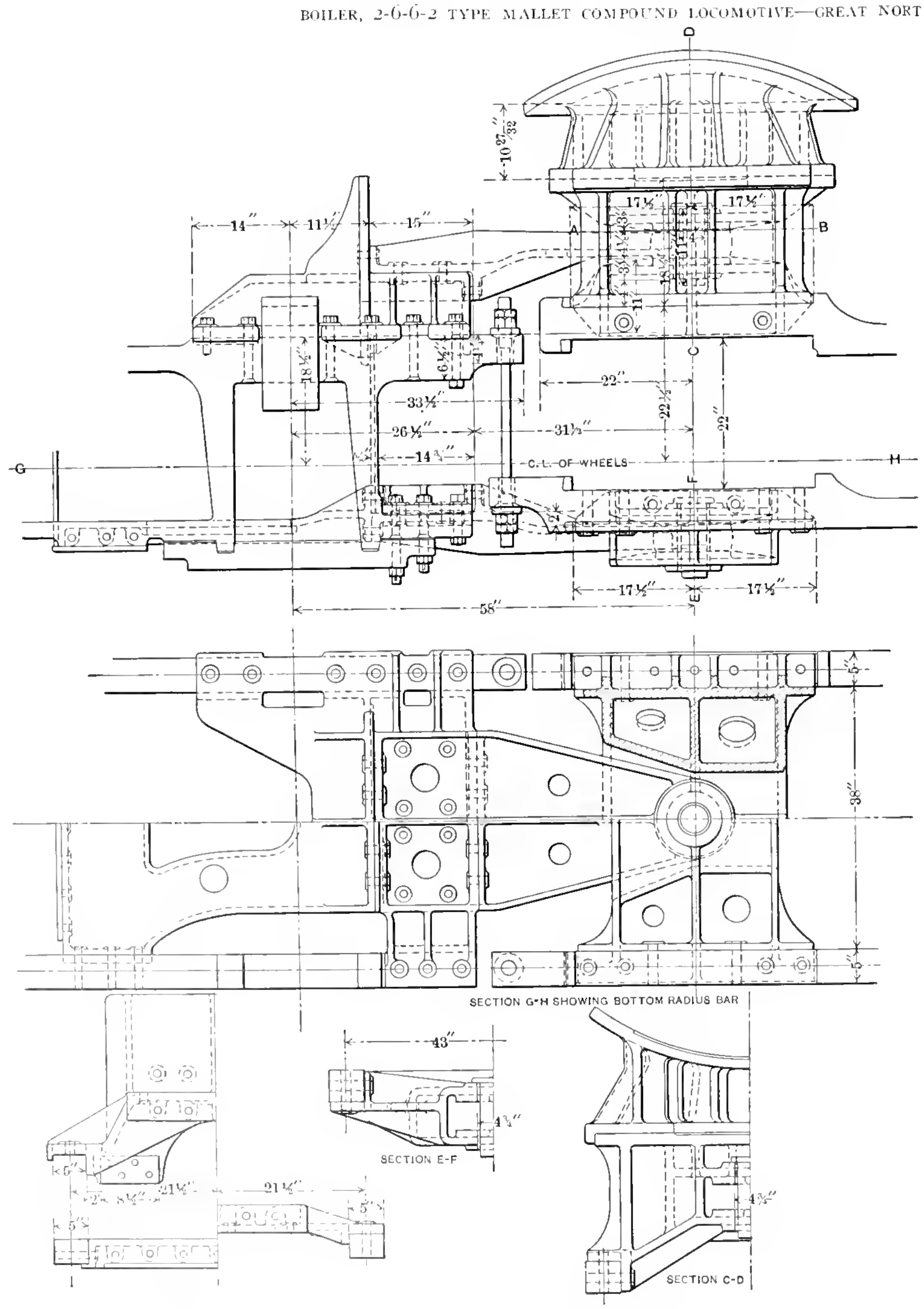
Service	Pusher	Freight
Total weight, lbs.	355,000	302,650
Weight on drivers, lbs	316,000	263,350
Tractive effort, lbs.	71,600	57,940
Diameter of drivers	55″	55″
Diameter of cylinders	$21\frac{1}{2}$″ and 33″	20″ and 31″
Stroke	32″	30″
Diameter of boiler	84″	72″
Steam pressure, lbs	200	210
Rigid wheel base	10′	9′ 10″
Driving wheel base	30′	28′ 11″
Total heating surface, sq. ft	5,658	3,906
Grate area, sq. ft.	78	53.4
B. D. Factor	698	820
Heating surface ÷ volume cylinders	271	229
Grate area ÷ volume cylinders	3.75	3.13
Total weight ÷ total heating surface	62.75	77

Reference can be made to the description of the previous locomotives for a discussion of the general features of the Mallet compound type of locomotives as illustrated by these examples.

* See AMERICAN ENGINEER AND RAILROAD JOURNAL, Aug., 1906, p. 300.



BOILER, 2-6-6-2 TYPE MALLET COMPOUND LOCOMOTIVE—GREAT NORTHERN RY.



FRAME CONNECTION, MALLET COMPOUND LOCOMOTIVE—G. N. RY.

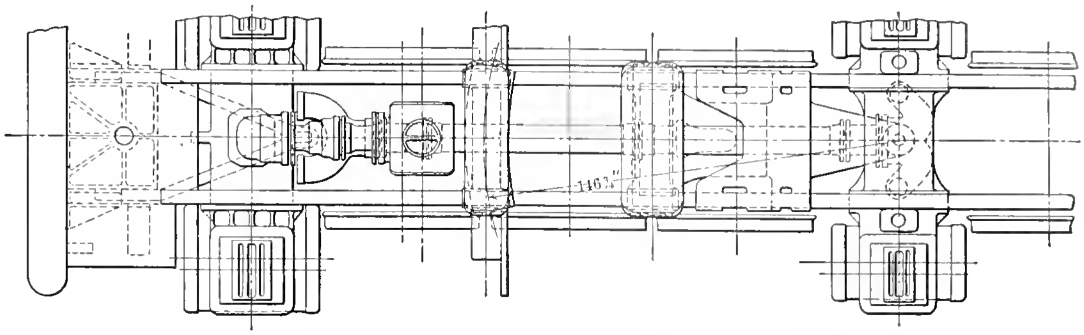
and a few of the more interesting details only will be considered here.

The boilers are of almost exactly the same size as the ones fitted by the same company to an order of Pacific type locomotives built for the Chicago, Burlington and Quincy Railway about a year ago.* The tubes are 2¼ in. diameter and 21 ft. long. There being 301 of them, this gives a sectional area of tubes of 1,195 sq. in., or 29.5 per cent. of the sectional area of the boiler at the front end. The same proportion for the pusher engines is 31.5 per cent. and for two other recent heavy freight engines is 32 and 30.5 per cent. The mud ring is 5 in. wide on all sides, and the water space is given a good clearance toward the crown sheet, it being increased to 8¼ in. at this point on the back head. The dome, as will be seen in the illustration, is a steel casting in one piece, with the joints for the double ported throttle and the outside steam pipes forming part of the same casting. The construction of the throttle and its chamber was illustrated in the October, 1906, issue, mentioned above. The arrangement of the front end, which is much simplified by the absence of the steam pipes, is shown in one of the illustrations.

The connection between the two sets of frames is very similar to that used on the previous engines, differing principally in being a little lighter. A different type of saddle, which is stronger and probably lighter than the usual box design used in the earlier order, is found in this design. The details at this point are evident in the illustration of the frame connection.

The spring centering device for guiding the front set of frames

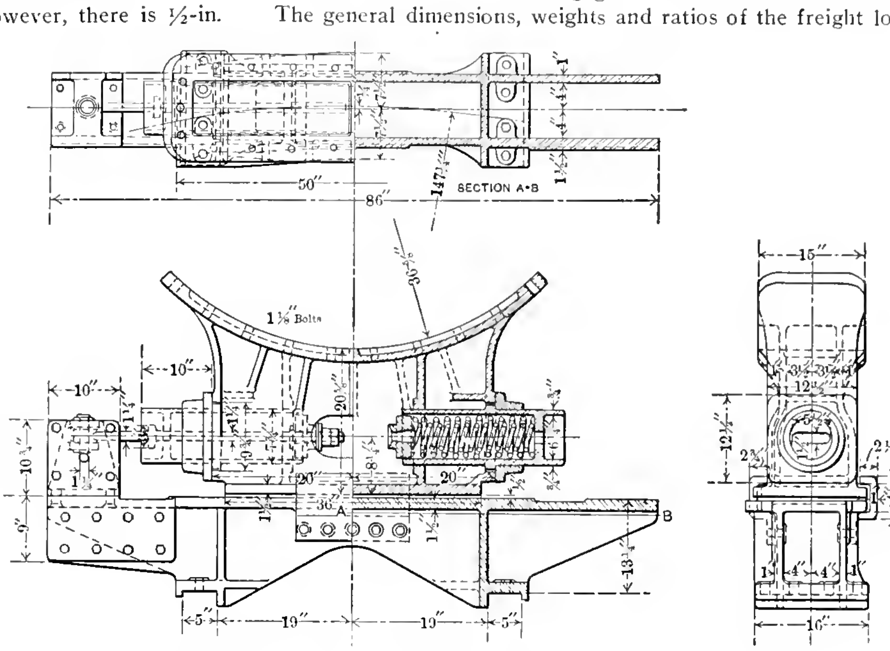
* See AMERICAN ENGINEER AND RAILROAD JOURNAL, Aug., 1906, p. 300.



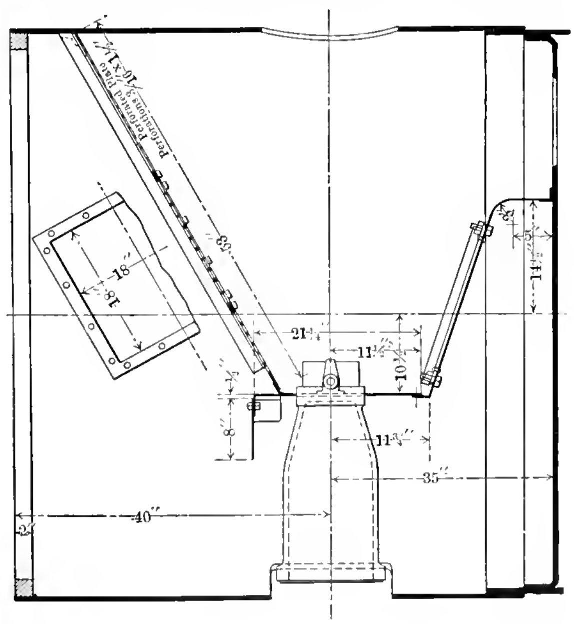
PLAN, 2-6-6-2 TYPE MALLET COMPOUND LOCOMOTIVE—GREAT NORTHERN RAILWAY.

is the same as that used before, and is shown herewith. Briefly, it consists of a saddle fastened to the boiler shell, which extends down and can form a bearing on a cross tie across the top of the frames directly below it. Normally, however, there is ½-in. clearance at this point. Within the saddle casting are arranged two sets of coiled springs enclosed in housings, having bearings so arranged as to permit free inward movement and to resist outward movement by the compression of the springs. The spring cap which has free movement within the spring casting or housing is connected to a rod which is hinged at its outer end to an extension of the frame cross tie. This rod also has a boss forming a ball joint at the outer end of the spring casting. Thus, the movement of the front set of frames is resisted by the spring on the side toward which it is moving. Any desired amount of initial compression can be given the springs by means of the nuts on the inner end of the rod, access to which is provided in the saddle casting. This spring centering device is located between the first and second pairs of drivers of the front set. It also forms the only connection between the front end of the boiler and the front set of frames, which will prevent them dropping away from the boiler. This connection is made by 40 x 1 in. plates, front and rear, fastened to the cross tie and lipping over the flange on the saddle, as shown.

The weight of the front end of the boiler is carried by a bearing between the second and third sets of drivers. This bearing does not restrict movement in any direction except vertically.



FRONT FRAME SPRING CENTERING DEVICE, MALLET COMPOUND LOCOMOTIVES.



FRONT END ARRANGEMENT, MALLET COMPOUND LOCOMOTIVE.

The construction of the receiver and exhaust pipes with their ball and slip joints was shown in the previous article, as was also the M'Carroll air reversing gear used on these locomotives.

The general dimensions, weights and ratios of the freight locomotives are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	57,941 lbs.
Weight in working order	302,650 lbs.
Weight on drivers	263,350 lbs.
Weight on leading truck	17,900 lbs.
Weight on trailing truck	21,400 lbs.
Weight of engine and tender in working order	450,000 lbs.
Wheel base, driving	28' 11"
Wheel base, rigid	9' 10"
Wheel base, total	43' 7"
Wheel base, engine and tender	72' ¼"
RATIOS.	
Weight on drivers ÷ tractive effort	4.55
Total weight ÷ tractive effort	5.21
Tractive effort × diam. drivers ÷ heating surface	820.00
Total heating surface ÷ grate area	73.00
Firebox heating surface ÷ total heating surface, per cent	5.10
Weight on drivers ÷ total heating surface	67.50
Total weight ÷ total heating surface	77.00
Volume equivalent simple cylinders, cu. ft.	17.10
Total heating surface ÷ vol. cylinders	229.00
Grate area ÷ vol. cylinders	3.13
CYLINDERS.	
Kind	Mallet Comp.
Number	4
Diameter	20" and 31"
Stroke	30"
Kind of valves	Bal. Slide
Valve gear	Walschaert
WHEELS.	
Driving, diameter over tires	55 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	9½ × 12 in.
Engine truck wheels, diameter	30 in.
Engine truck, journals	6 × 12 in.
Trailing truck wheels, diameter	30 in.
Trailing truck, journals	6 × 12 in.
BOILER.	
Style	Belpaire
Working pressure	210 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	116⅛ × 66¼ in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	5 in.
Tubes, number and outside diameter	301—2¼ in.
Tubes, length	21 ft.

Heating surface, tubes	3,708 sq. ft.
Heating surface, firebox	198 sq. ft.
Heating surface, total	3,906 sq. ft.
Grate area	53.4 sq. ft.
Center of boiler above rail	116 in.
TENDER.	
Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	8,000 gals.
Coal capacity	13 tons

ROUNDHOUSE BETTERMENT WORK.

By J. F. Whiteford.*

In the general description of the "Betterment Work" lately instituted on the Santa Fe System, which was published in the December, 1906, issue of your journal, but little space was devoted to its application to roundhouses (December, 1906, page 474), as the work in this department had barely commenced.

The installation of a system of rewarding individual ability through increased pay has progressed so satisfactorily in this department that a brief description of the work will be of interest to your readers, since there are many conditions encountered that vary considerably from the regular shop work which necessitate the employment of other methods than those already described.

In the machine shop the application of such a system is comparatively easy, since it is possible to determine exactly the depth of cut and speed for the various machines for each quality of metal, and schedules, providing a time allowance for each individual job, can be arranged accordingly, the bonus being determined by the regular curve (December, 1906, page 465).

In erecting work the problem is more difficult, since the amount of work necessary to complete a certain piece of work may be greater or less than the preceding job, as for example, on a shoe and wedge job on a locomotive, more lining may be required, more dressing of jaws and more new work at one time than another, consequently it becomes necessary to allow a margin on schedules on this class of work, so that a workman may average a fair compensation in return for special effort. Experience has proven that a shop organization can be much improved by specialization of work, and schedules on erecting work are arranged to good advantage on that basis, as, owing to the large number of engines in for repairs at one time, there is always sufficient work of each kind to occupy the men on schedules.

The roundhouse, however, presents an entirely different condition, for, while the shop foreman is able to plan the work one or two days, or even a week, in advance, and can determine from the reports furnished him what work will be necessary on the engines on the waiting track, the roundhouse foreman has no knowledge of what work is required until the engine reaches the ashpit.

Again, while the shop foreman has days or weeks to complete his work, the roundhouse foreman is confined to minutes or hours at the most, necessitating considerable elasticity in handling his force, and this condition permits neither a stated number of men to perform a certain job nor allows one job to be finished if more important ones arrive, and the item of waste in delay and waiting for work precludes the specifying of certain work to be performed by certain men.

It is readily seen that any system of schedules which would not admit of any job being performed either individually or in conjunction with other work, or that did not provide for the work to be done by any number of men, would be of no value whatever in expediting roundhouse work, and it is on this account that the railroads which have similar systems of rewarding special effort in their shops, have been unable to handle it successfully in all departments of roundhouse work.

This difficulty has been overcome by arranging the schedules on a time allowance rather than a money basis, in the following manner:

First.—By arranging schedules on all operations in detail so that credit may be given for each individual piece of work performed.

Second.—By making all schedules on a one-man basis and dividing the time allowance according to the number of men used.

* General Roundhouse Inspector, Santa Fe System.

The following schedules illustrate the methods employed:

Schedule Number.	Description.	Groups.	Hours.
1261	Reducing and lining back end outside main rod brasses	ABCDEGHIJK	1.6
		FLMNRSTUVX	2.6
		P	3.2
1271	Reducing, refitting and lining back end inside main rod brasses	All	5.0
1275	Applying new brasses, front end inside main rod	All	3.6
1279	Relining only, back end inside main rod brasses	All	3.0
1305	Keying up back or front end outside main rod or side rod, not otherwise included	All	0.1
1308	Dressing one main rod end or strap when necessary	All	1.0

Note.—The letters refer to groups of certain engine classes, arranged in this manner for convenience.

The standard time at which 20 per cent. bonus is paid for performing the work in each schedule is shown in tenths of hours for one man, and where more men are used, the time shown is divided according to the number of men, and bonus is paid to each in proportion to his hourly rate.

From the examples of schedules on rod work, it will be noticed that all operations have been scheduled sufficiently in detail, so that the proper time allowance can be credited to each man according to the work performed, though special schedules of a blanket nature are often arranged to cover boiler-washing, boiler work, etc., where the work performed by certain gangs is considered as a unit. An example of this is as follows:

"For performing all grate and ashpan work, boring flues and doing all necessary hot work on engines turned during each shift, a bonus as per table below will be paid to the boiler gang, and prorated according to the wages earned. No bonus to be paid unless work performed is satisfactory to the foreman. No engines to be counted on which overtime is worked; no engines counted if a failure due to this work occurs on the following trip."

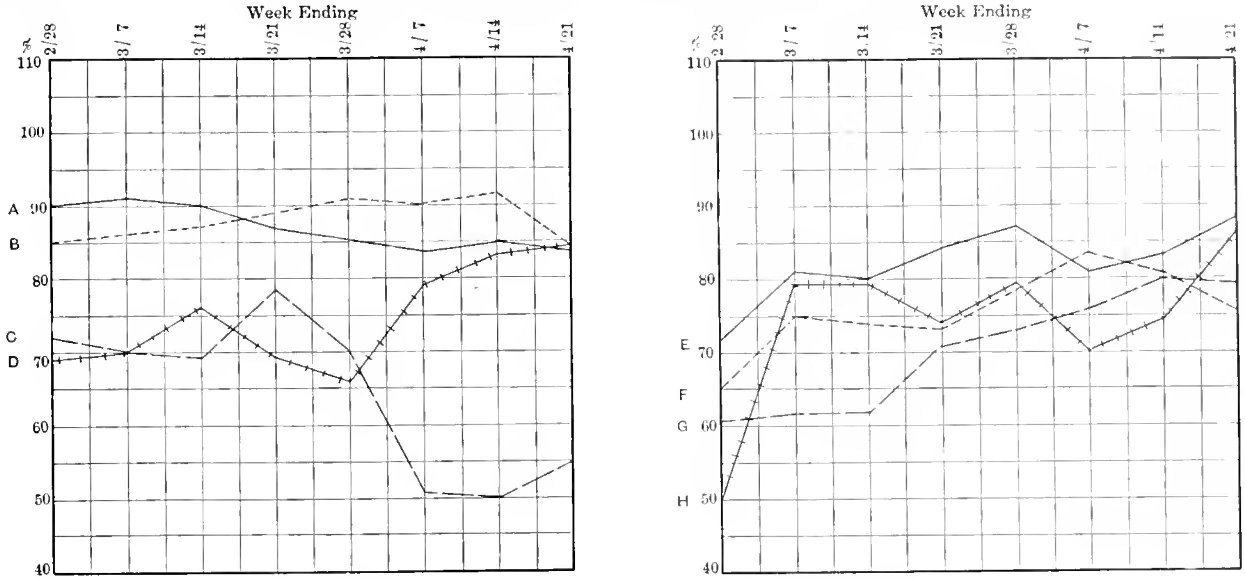
	Bonus		
Engines.	6 Men.	5 Men.	4 Men.
13	$0.00	$0.40	$0.80
14	0.00	0.60	1.00
15	0.00	0.80	1.20
16	0.60	1.00	1.40
17	0.80	1.20	1.60
18	1.00	1.40	1.80
19	1.20	1.60	2.00
20	1.40	1.80	2.20
21	1.60	2.00	2.40
22	1.80	2.20	2.60
23	2.00	2.40	2.80
24	2.20	2.60	3.00
25	2.40	2.80	3.20
26	2.60	3.00	3.40
27	2.80	3.20	3.60
28	3.00	3.40	3.80
29	3.20	3.60	4.00
30	3.40	3.80	4.20

The ruling that no bonus is paid if the work performed is not satisfactory to the foreman, minimizes the imperfections in workmanship, and this is further emphasized by the fact that the earnings are materially reduced if a failure occurs on this class of work on the succeeding trip. The men soon realize that a "stitch in time saves nine," and that slighting of work one day means considerable loss of bonus when the engine returns, so that each man exerts himself to get the engines out in the best possible condition.

It frequently becomes necessary for the roundhouse foreman to shift men in order to furnish power promptly to the transportation department and delays to individual jobs are often occasioned by waiting for work from the machine or blacksmith shops, all of which would nullify any effort to pay bonus on individual schedules.

In order to provide for these contingencies, and not restrict the shifting of men, and also to permit the men to profit by such benefits as may be derived by carrying on several jobs at one time, a collective feature was introduced where the total work performed in any one day by one man or gang of men is grouped and the total time allowance for all operations is taken as the standard time of the collective schedule, for the calculation of bonus.

By this method, a record of all work completed by each workman during the day becomes essential, but it is unnecessary to



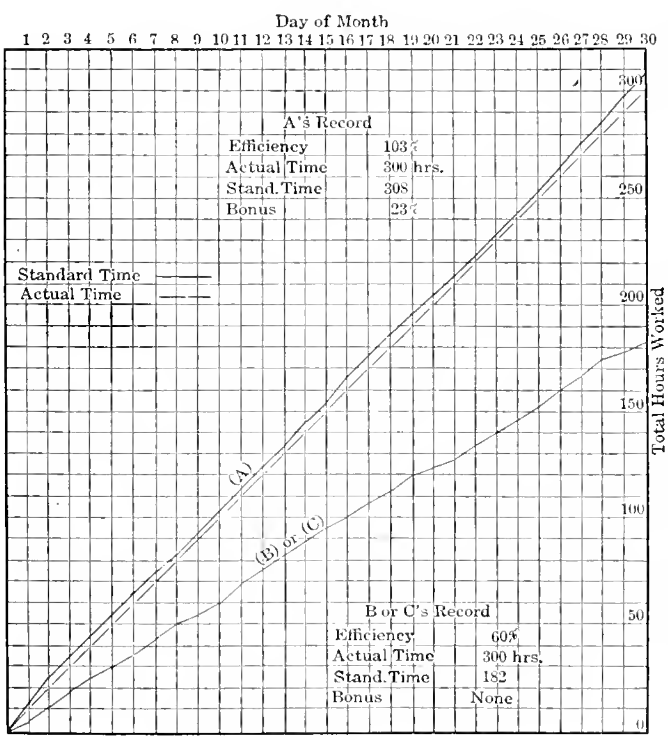
EFFICIENCY BY WEEKS OF SEVERAL LARGE ROUNDHOUSES.

know the exact hour any particular job was completed and clerks are employed to visit the workmen at intervals in order to give them credit for all operations performed, as this system of time-keeping has been found the most satisfactory.

With a systematic distribution of men and work, one clerk is able to attend to these duties in any of the roundhouses, though it has been found advantageous to secure clerks who have had practical experience in locomotive work, as their duties are such that they can materially assist in the supervision of repairs.

Delays between jobs, always a source of waste in roundhouses, are eradicated, as each workman realizes that every minute idled reduces his bonus earnings and they now inform the foreman when delays ensue, which is quite contrary to the former custom.

There is always a tendency, where work is required on short notice (and this condition is almost continuous in a roundhouse), to assign more men to the work than are necessary, all of which increases the cost of repairs, but the arrangement of schedules on a one-man basis, while permitting the necessary flexibility in handling the work, serves to discourage the employment of superfluous help, as this greatly affects the bonus earnings, and thus exerts a marked influence on the individual workmen.



INDIVIDUAL EFFICIENCY STATEMENT.

As a man gets but one-half the time allowance with two men on the job as when he is alone, it results in efficient team work, or produces a tendency to work by himself whenever possible.

Experiments have demonstrated that the more men work alone, the more efficient they become, and the following graph is submitted as evidence, the line "A" indicating the work performed by one man working alone, and the line "B" or "C" that performed by each when two men are working together, the record having been taken from the actual performance for thirty days on the same class of repair work.

The actual hours worked by each man is indicated by the broken line and the standard time allowance for the operations performed, by the heavy lines. The record shows that, at the end of thirty consecutive days "A" had 308 hours to his credit, or an efficiency of 103 per cent., while "B" and "C" working together, have but 182 hours each, or an efficiency of 60 per cent., for which work "A" earned bonus equal to 23 per cent. of his wages, while "B" or "C" earned no bonus.

Estimating the value of locomotives at $5.00 per hour, the gain by the performance of "A" is $40.00, standard time considered as a basis, while the performance of "B" and "C" results in a loss of $590.00, or a difference of $630.00, from which must be deducted $17.25, the amount of bonus paid to "A." The value of distributing the work as much as possible is very evident.

The efficiency of each workman is the relation the standard time of the work performed bears to the actual time consumed, and the foregoing serves to illustrate the ease with which the most efficient men can be readily located. Statements showing the efficiency percentage of each man are furnished at intervals to the master mechanics in order that the incompetent may be located and replaced. This has served to improve the force at all points.

When the amount of work fluctuates, as is usual in roundhouse work, it has always been a difficult matter for accurate comparisons to be effected for the same point for different periods, as any comparative basis which does not consider the quantity of work performed, is erroneous in the extreme, and the usual basis of the average cost per engine is one which possesses no value whatever.

On the Santa Fe, a method has been employed for some time wherein comparisons of the handling expenses are made on the unit cost, a unit allowance having been determined for each operation in connection with the turning of engines, which method was fully described in the issue of your journal of December, 1906, page 474, but a comparison of repairs has been recently arranged by means of an efficiency report which shows the performance of the repair force.

The efficiency for a roundhouse is determined by comparing

the relation of the total standard hours of all operations performed and the total actual hours, and this data is compiled at the close of each day's work, which enables the efficiency of any point to be determined by days, weeks, or months.

The accompanying graphs show the efficiency record by weeks of several of the large roundhouses, showing how these reports are arranged and distributed to the various mechanical officials, enabling them to know positively at a glance what was previously only a matter of conjecture.

The following data, taken on a division operating the heaviest power, in a bad water district, with adverse labor conditions, indicates the relation the efficiency of a force bears to the total expenses and serves to illustrate the value of records of this nature.

The figures are for three consecutive months immediately following the introduction of the new system, and include the efficiency, the handling expenses, the repair costs and the average time consumed in turning power:

Efficiency	Handling Expenses.	Repairs.	Average Time Turning Power.
35%	$6,399.01	$9,128.80	10.4 hours
58%	5,990.24	8,866.58	8.7 "
82%	5,236.83	6,727.44	8.3 "

The increase in the efficiency resulted in a substantial decrease in the average time consumed in turning power and also a reduction in the cost of handling and repairs, which includes all expenses incidental to the installation of the new methods.

It is noticeable that the majority of the points shown in the second graph are located in territory where there has always been difficulty in securing labor, and it is worthy of note that since the installation of the new system at these points the length of service of the men has increased over 50 per cent., and the number of steady men is gradually increasing, while a more cordial relation between the men and foremen has been effected, as each workman realizes that it depends on his own ability whether his services are found worthy of promotion or otherwise.

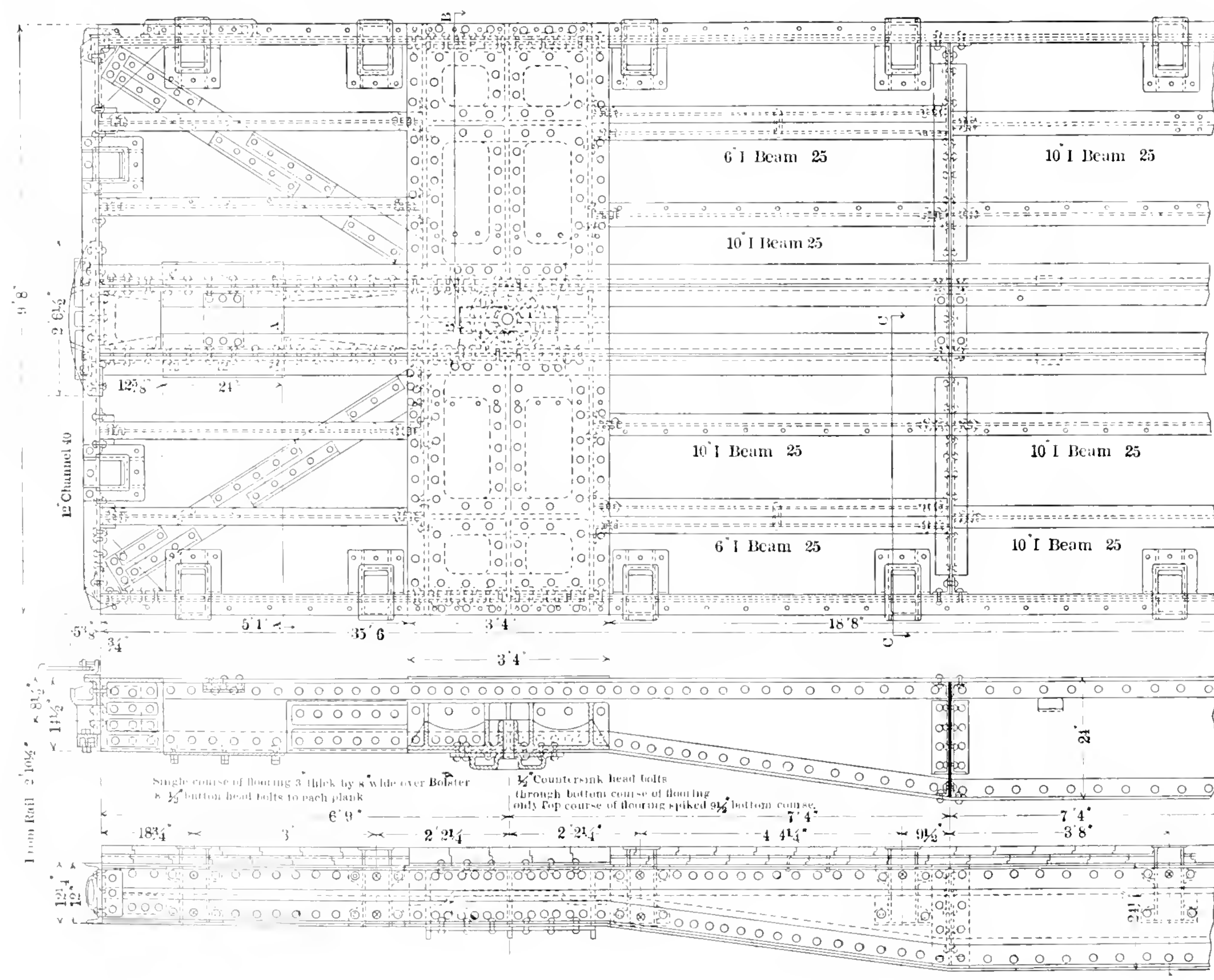
The introduction of the system has made such progress that the majority of the work in the larger roundhouses is now covered with schedules, and it is being introduced in the smaller places as rapidly as possible.

The general results which have been obtained may be noted from the following comparison of roundhouse expenses for the month of February with those of a year previous on one grand division where the system has been introduced at all points:

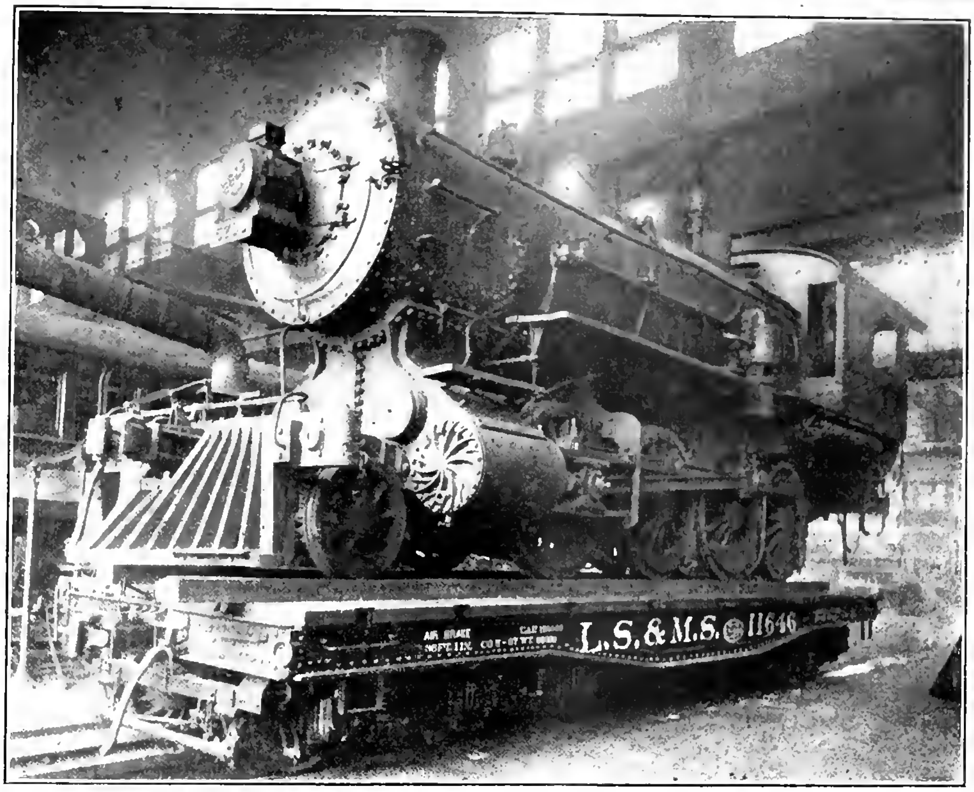
	Engines Handled.	Handling Expenses.	Repairs.
1906	5,036	$10,110.69	$15,517.01
1907	5,929	8,328.10	12,830.90

With an increase of 16 per cent. in engines handled, the expenses have decreased over 17 per cent., an actual saving for the month of $4,468.30, or, on the basis of engines handled about $9,000.00, which would mean a yearly saving on that division of over $100,000.00.

Additional advantages of this system are improved supervision, a more complete record of work done than was possible under the old system, and a more accurate distribution of labor charges, all of which are due to the method of checking and recording each individual operation performed. The economies resulting from the improvement in handling power are such that they cannot be reduced to a money basis, though they produce a marked increase in the earning capacity of each locomotive.



75-TON STEEL FLAT CAR—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.



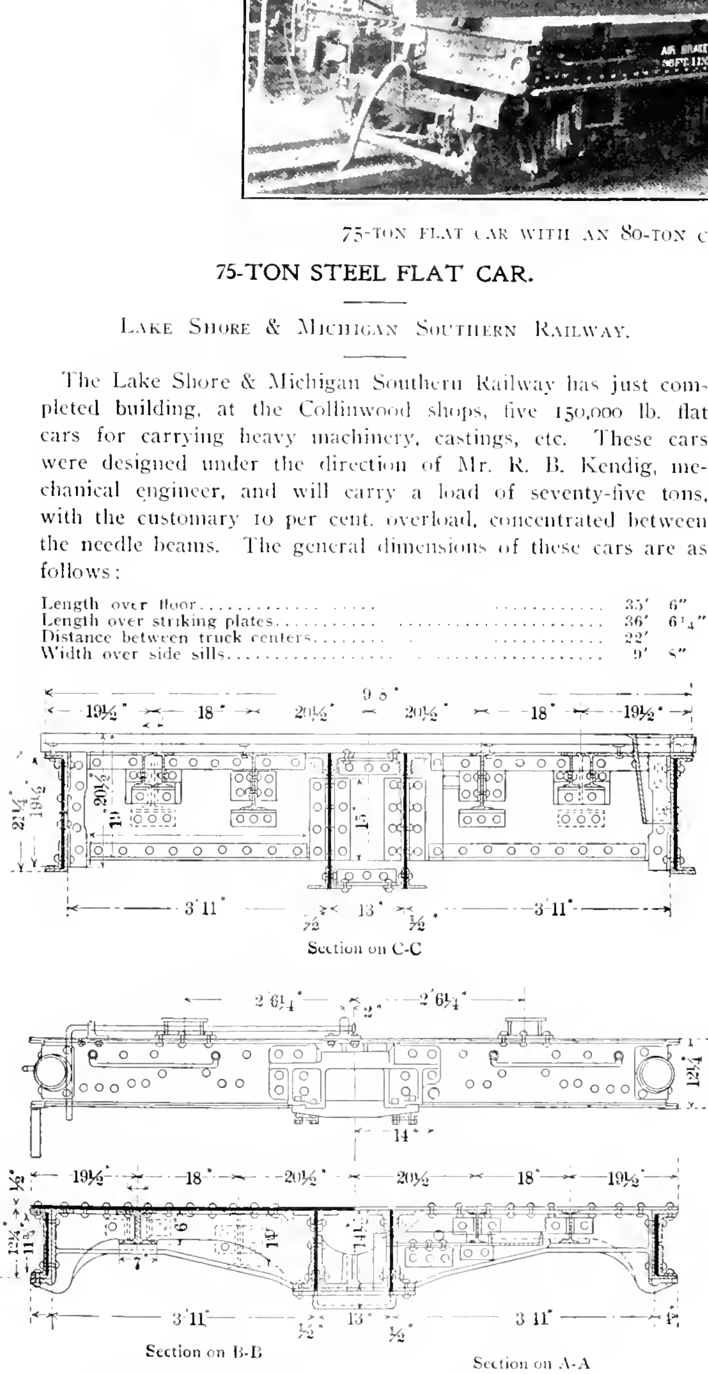
75-TON FLAT CAR WITH AN 80-TON CONSOLIDATION LOCOMOTIVE LOADED ON IT.

75-TON STEEL FLAT CAR.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

The Lake Shore & Michigan Southern Railway has just completed building, at the Collinwood shops, five 150,000 lb. flat cars for carrying heavy machinery, castings, etc. These cars were designed under the direction of Mr. R. B. Kendig, mechanical engineer, and will carry a load of seventy-five tons, with the customary 10 per cent. overload, concentrated between the needle beams. The general dimensions of these cars are as follows:

Length over floor	35' 6"
Length over striking plates	36' 6¼"
Distance between truck centers	22'
Width over side sills	9' 8"



END VIEW AND CROSS-SECTIONS OF 75-TON STEEL FLAT CAR.

Width over flooring	9' 10"
Height, top of rail to top of floor	3' 10½"
Truck, wheel base	9' 6"
Truck, diameter of wheels	33"
Truck, journals	5" x 10"
Weight	65,000 lbs.

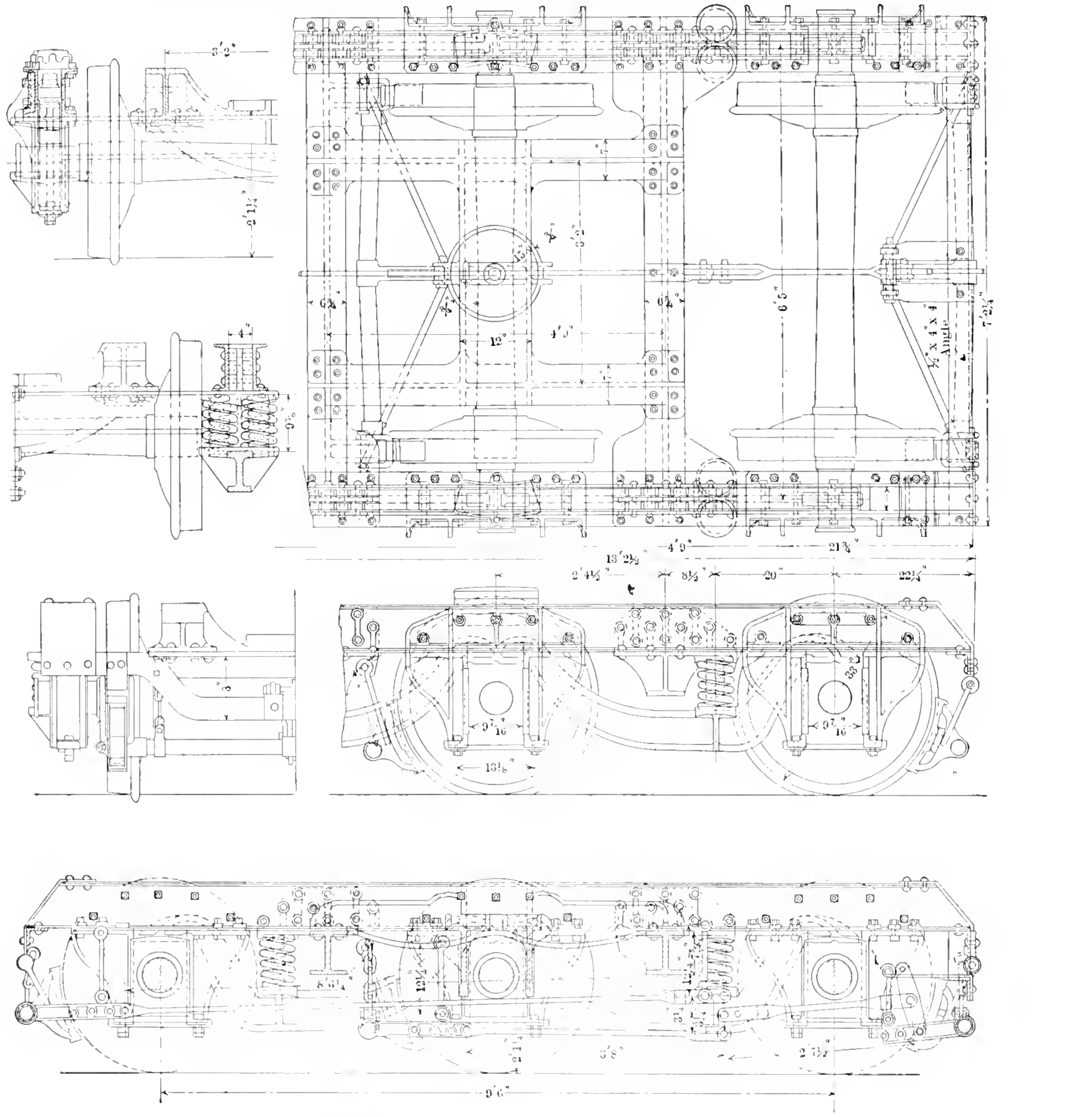
The center sills are continuous for the entire length of the car and consist of a ½-in. plate, 24 in. deep, for a distance of 7 ft. 4 in. at the center of the car, and 14½ in. deep at the bolsters, with two 4 x 4 x 13/16 angles riveted, back to back, to the upper edge and two 4 x 4 x ½-in. angles riveted along the lower edge. The inside angles along the lower edge extend through the bolster only, because of the rear draft lug. This lug is specially heavy and backs up against the bolster center sill filler casting.

The side sill is of a slightly different construction, the ½-in. plate being 19½ in. deep for a distance of 7 ft. 4 in. at the center of the car and 11¾ in. deep at the bolsters. Angles are riveted on each side of this plate at both the top and bottom edges, but the flanges are all turned outward. The center and the side sills are securely tied together by the heavy cast steel members of the body bolster and by the ½-in. top plate, which is the same width as the bolster, 3 ft. 4 in. At two points between the body bolsters the sills are tied by a ½-in. plate with two angles riveted along both the top and bottom edges, as shown. This plate is secured to the sills by angles.

Extending between the cross braces and parallel to the longitudinal sills are a number of stiffeners or floor supports. They are 10-in., 25-lb., I-beams and are attached to the cross braces and bolsters by angle plates. The floor supports nearest the junction of the bolster and the side sill consists of two 6-in., 12¼-lb., I-beams, in order to afford sufficient clearance for the truck wheels. The floor supports between the bolster and the end sill are 6-in., 12¼-lb., I-beams.

The end sill is a 12-in., 40-lb., channel. A diagonal brace extends from the gusset plate at the corner of the car underneath the floor supports, to the body bolster at the center sill. This brace consists of a plate with angles riveted on its top side between the floor supports to stiffen it. The coupler striking plate is of cast steel. The end sill is reinforced between the center sills by a steel casting, which is also utilized as the front draft lug. Westinghouse friction draft gear is used.

Stake pockets of heavy construction are attached on the inside of the side sills, their tops being flush with the top of the



SIX-WHEEL TRUCK FOR 75-TON FLAT CAR.

floor. The flooring consists of two courses of 1¾-in. plank. The first course is fastened to the side sills and to two of the intermediate floor supports by ½-in. countersunk head bolts. The top course of flooring is spiked to the bottom course. Because of the cover plate at the bolster a single course of flooring is used, 3 in. thick, each plank being secured by eight ½-in. button head bolts.

It is, of course, necessary to build a car for this service as low as possible and for this reason considerable difficulty was encountered in designing the truck. The side frames each consist of two 8-in., 21¼-lb., channels, placed back to back with a space of 4 in. between them. They are spaced apart by thimbles and also by projections on the ends of the transom castings. The end pieces are 4 x 4 x ½-in. angles. The transoms are of cast steel I-section and the center bearing piece is also of cast steel. As may be seen from the drawing the center plate is only a short distance above the middle axle and the flanges on the center bearing casting extend below the axle at each side. The equalizers are of cast steel. Symington special 5½ x 10-in. journal boxes are used, also Perry roller side bearings.

Within five years New York City has doubled its business in the sale of mining and industrial machinery and is now the world's greatest market for all the principal types of machinery and tools—*New York Sun.*

Coaling with Locomotive Cranes.—The practical limit of a locomotive crane in coaling locomotives is said to be about 70 engines a day. The fact that it can unload direct from flat bottom cars is much in its favor. Three of these cranes, besides handling cinders, show the following cost for two years' operation, coaling direct from cars:

Average tons handled per day	195
Interest and depreciation	1.5 cents
Operation	0.5 "
Maintenance	0.5 "
Storage	7.5 "
Total cost per ton	10.0 "

—*Report of Committee, Amer. Ry. Eng. & M. of W. Assoc.*

The Locomotive Appreciated.—The advocates of electrification must compete with what is probably the most remarkable prime mover in existence. Hampered in every way by limitations of space and weight, the locomotive designer has produced a power plant which is lower in first cost than any other form of fuel-burning power plant that is known, costing only a fraction of the price that would be asked for stationary power equipment of equal capacity. Its operating efficiency in steam generation, in spite of abnormal proportions and conditions, compares favorably with that of any steam boiler; while its economy in steam consumption has not been surpassed by that of any noncondensing engine.—*William Duane in The Third Rail.*

THE METHODS OF EXACT MEASUREMENT APPLIED TO INDIVIDUAL AND SHOP EFFICIENCY AT THE TOPEKA SHOPS OF THE SANTA FE.

By Harrington Emerson.

"Too much emphasis cannot be laid upon the fact that 'Standardization' really means 'Simplification.' "—*F. W. Taylor—(The Art of Cutting Metals).*

Shop efficiency pays. By shop efficiency is meant a careful investigation and betterment of all conditions, so that with the same effort men can accomplish more. To secure the co-operation of the worker with the management in cutting out unnecessary wastes at the Topeka shops of the Atchison, Topeka & Santa Fe Railway, he is offered an increase of as much as 20 per cent. If by means of special strength or skill he does more work than normal he is given *all* the gain, for instance, if he does in one hour a job standardized at two hours he receives two hours' pay for an hour's time. The management gains, firstly, by the elimination of unnecessary wastes, although it gives the worker a 20 per cent. increase, and it particularly gains by the increased efficiency of its machines and other equipment, which results in a larger output without the necessity of increasing the capital investment. The actual results at the end of two years of systematically organizing the Topeka shops on an *Efficiency* basis were:

To increase the average pay of the men	14.5%
To decrease the unit cost of production	36.3%
To increase the shop output	57%

There is no reason why all the men should not earn at least a 25 per cent. increase above standard wages, and many of them do, 40 per cent. of them earning a 25 per cent. increase and better. The average efficiency of all the men in the month of April, 1907, was 94.2 per cent. Two years ago it was about 60 per cent. Although the average of all the workers is 94.2 per cent. there are many who are better, many who are not as good. One man earned 105.4 per cent. above standard wages. Four men drawing full pay were 64.7 per cent. below normal, doing only one-third of what they should have done. These figures are not guessed at, but taken from the actual operations of this large locomotive repair shop in which every job is standardized and the efficiency of every man determined. Now, the system is perfected and it costs no more to keep it in operation than the former barren methods. The successive steps of progress were:

1. A permanent and standard *method* for determining costs of every operation.
2. The betterment of all conditions.
3. The determination of a standard cost of *every* operation.
4. A comparison of actual costs with standard costs as to every operation.
5. The guarantee to each individual worker of standard wages, and the payment of an added amount based not on the piece or on output, but on efficiency.
6. A check and reward of each foreman on the basis of the efficiency of those under him.
7. A check of the efficiency of the shop as a whole from month to month.
8. The use in all accounting, of *standard costs,* not *accidental* actual costs.

Editor's Note.—After thirty years of experience in developing the efficiency of men at their work of many kinds, Mr. Harrington Emerson became convinced that the average efficiency of any industrial concern is exceedingly low. Some do not reach 25%, others are higher; very few, railroads included, reach as high as 50%.

While capital and labor, or rather employer and employee, waste their strength in an embittered quarrel as to their relative shares of joint production, they are together wasting so much that, if labor, without these wastes should receive the entire present share of capital and organizers; if capital and organizers, without these wastes, should receive in addition to their own, the entire present share of labor, there would be still a large surplus.

It was Mr. Emerson's privilege to have an opportunity to apply, on a somewhat large scale, in the shops and roundhouses of the Santa Fe, methods which he believed would, by increasing the efficiency, demonstrate the entire feasibility of increasing the pay of the workers, yet result in diminishing unit cost to the company. In addition Mr. Emerson set himself the task of proving to the management that a body of skilled, reliable, friendly workers could be permanently secured; of proving to the workers that without any unreasonable work effort on their part their pay would be advanced far beyond the wage scale for similar occupations elsewhere, and that the management would not only not begrudge them the increased wages, but welcome the increases as evidence of better and more economical conditions.

As appears on the diagrams, the movement one way or the other of a single line shows whether the shop is improving or retrograding. As to each foreman, a single comparative figure shows what is doing, absolutely irrespective of the kind of work, and as to individual workers; not only does the monthly efficiency figure show absolutely what each is doing, but the efficiency of each individual operation is ascertainable.

It was not an easy task to work out this problem, undertaken jointly by the "Betterment Department" on the one hand and by the superintendent of the shops, Mr. John Purcell, and his foremen on the other.

While the ideal end was never lost sight of, every step was taken with care and deliberation, and for every two steps forward one was taken backwards as difficulties developed which it was found easier to go around than to break through. In the whole course of three years during which the work was being perfected it was not found necessary to remove or discharge a single worker or foreman, and if, at first, there was occasional friction, in the end as to every step there was complete and unanimous accord.

At the last meeting on this subject, attended by representatives of the auditing department, of the mechanical accounting department, of the superintendent of motive power's office, and by the superintendent of shops and his betterment work assistants, and also by the general betterment organization, the agreement as to all the radical points, as to final and radical steps necessary, was unanimous.

Each of the previous seven moves or steps had been a separate problem. A brief outline of the successive steps follows:

A Permanent and Standard Method of Determining Costs.

Costs are of two kinds, those that can be located and those that cannot be located. The work of a machinist and also of his machine can be located. The problem of cost determination reduces itself into apportioning to each man and each machine, the indirect or unlocated costs in addition to the direct or located costs. To do this, each item of indirect cost is apportioned either to men or to machines or partly to one and partly to the other. Having thus secured two grand totals, one of indirect men costs and the other of machine costs, the totals are subdivided to various departments. Whereas the indirect cost as a whole may be 75 per cent. of the pay roll, within the confines of a department, the percentage may vary from 15 per cent. up to 400 per cent, showing how absolutely inaccurate the usual method is of applying the same flat rate of factor, surcharge or burden to all departments alike.

Having secured substantial accuracy by apportioning each class of costs, men-costs and machine-costs, to each department, no great errors can arise in any particular method of subdividing departmental charges to specific men and machines. The simplest method is therefore preferable. The method adopted at Topeka was to assess indirect men-costs as a percentage on applied labor, to assess all direct and indirect machine costs as a yearly charge on the inventory value of the machines. To ascertain the hourly rate for each machine, the yearly charge to the machine was divided by 2,400 hours, it being assumed that the machine worked 80 per cent. of the time. If there were any gains in simplicity to be effected by modifying this general method within the boundaries of a department there was no hesitation in allowing common sense to govern. For instance, when it was discovered that a direct worker on a shear did 200 different small jobs a day, he was at once considered an indirect worker, and when a machine rate worked out at $0.01 an hour, the machine was promptly relegated to the list of indirect machines. There is no sense in an accuracy that makes the distribution of cost amount to more than the cost itself.

Power is determined at so much per horse power and floor space at so much per square foot for the plant as a whole and charged on a flat basis to each department. If one department is further from the power house than another and therefore suffers a greater line drop loss, this loss is considered a plant loss, not a department loss, and it is borne in the form of a general increase in power cost. What would one think of a

gas or water company which charged more for gas or water because the customer was farther from the central plant or which charged repairs of mains to the customers served by the mains, yet just this kind of cost accounting has brought the whole art of factory cost accounting into deserved disrepute!

With a machine rate, man rate, and man surcharge provided, and time known, the cost of every operation is at once determinable.

FACTS KNOWN.

Machine rate	$0.40 per hour
Man rate	0.30 " "
Man surcharge	80%
Time of operation	2 hours

COST OF OPERATION.

Machine rate	$0.80
Man's pay	.60
Indirect expenses	.48
Total	$1.88

It is at once evident that the cost (not including material) varies with the time, that if an operation takes one hour it costs half as much as if it takes two hours. The time cost of machine shop operation is very nearly one dollar an hour, rarely as low as $0.80, for the average combination of man and machine.

In striving for shop efficiency nothing is more important than the exact determination of a fair standard time. Any guesswork, any haphazard application of piece-work schedules in use elsewhere is sure to result in disaster.

These time and cost determinations are for the purpose of promoting shop efficiency and not for the purpose of enabling the accountants to balance the books. If the books show that the total costs in a given month are $105,000, but the total shop cost for all the items amounts to $100,000 it is easy to reconcile the two methods by adding in the office 5 per cent. to the shop costs. If a shop is temporarily running on half time it is absurd to assume that the shop cost of each operation is doubled. The indirect shop costs are based on an average rate for power, an average charge for floor space, an average charge for supervision and an average charge for machine maintenance. The direct costs are based on the average wage rate and average cost of materials, and these average costs are not subject to hourly or daily variation, but only to slow changes based on averages of months or years.

The Betterment of All Conditions.

This was a very large task and involved everything that could be done to improve machines, tools, operation and general comfort of the men, as, for instance, better lighting and heating It is evident that standard costs could not be determined until conditions were in the main standardized.

A Determination of Standard Costs.

This part of the work was most completely and conscientiously carried out. The motto adopted and promulgated by the authorities in a pamphlet distributed to the men was:

"Fairness, not Favoritism.
Individuality, not Subserviency.
Efficiency, not Drudgery."

Painstaking, accuracy, judgment, and fairness in ascertaining standard methods of performing work, is the foundation on which a lasting reconciliation between employer and employee must rest, as well as the foundation on which all cost accounting must be based. The fame of Mr. Fred. W. Taylor, as the discoverer of high speed steels has overshadowed his even greater evidence of genius in being the first scientifically to standardize shop operations, to substitute for guesswork or spasmodic experiment, perfected scientific methods. Not only were the best men possible secured to carry out these investigations along the lines taught by Mr. Taylor, but the work was checked and counterchecked by many different officials. The procedure was as follows:

A time study of a job under actual working conditions by the regular worker was made by a practical man, a machinist, a boiler-maker, or a blacksmith, as the case might be. The machines and other conditions, tools, belting, speed, etc., were first adjusted. It made no difference whether the job under observation actually took a long or a short time. It was the duty of the observer to set down a reasonable and proper time. As a rule the times eliminated from standard were not those of reasonable work, but those of unnecessary waste.

Samples of Time Studies.

Finishing an air compressor piston rod.

Taking finishing cut	35 minutes
Looking for chain to sling it down	14 "
Looking for pad to put between chain and piston	8 "
Total time	57 minutes
Standard time adopted	36 "
Actual efficiency of observed operation	63.2 %

The gain is in the 22 minutes wasted.

Laying out and slotting brass collar fit in new cast iron driving boxes, all boxes over 9" brass fit. 20% steel cast iron.

	Actual Time.	Estimated Time.
Putting box on machine	35"	35"
Clamping down, setting box	8' 2"	5'
Cutting	14' 52"	14' 52"
Turning tool around	42"	42"
Cutting	11' 39"	11' 39"
Changing tool, grinding	2' 19"	1' 0"
Cutting	2' 56"	2' 56"
Changing tool	1' 56"	42"
Broken spring, time lost	46' 20"	
Cutting	53' 23"	40'
Changing tool and belts	1' 15"	1'
Cutting	3' 39"	3' 39"
Changing tool	1' 35"	50"
Cutting	5' 3"	3' 39"
Taking off box	3' 32"	2'
Total	2 37' 48"	1 28' 34"

Efficiency of observed time, 56.3%. Standard time adopted, 1.5 hours.

The main gain is in the 46′ 20″ of time lost on account of a broken spring.

Planing for guide fit one Penna. type crosshead, when gibs are old.

	Actual Time.	Time Allowed.
Pick up and place on machine	6' 4"	3' 5"
Set up job	22' 1"	12'
Adjust planer head	3' 7"	2'
Put in tool	1' 6"	7"
Run up planer bed	3"	3"
Set tool	2' 2"	1' 7"
Plane top gib	21' 2"	13'
Turn crosshead for resetting	4' 5"	3'
Set up cross head	18'	12'
Plane bottom gib	20' 8"	13'
Unset job	7' 4"	3'
Lift job off planer	5' 5"	3'
Total	109' 47"	65' 22"

Allow 1.2 hrs. (72 minutes). Efficiency, 60%.

These examples average about 60 per cent. efficiency, and this is a fair average in an average shop.

The time schedules at Topeka, made when the method was first introduced, and also the latest records show the following results between actual observed current times and standardized times subsequently realized by workers:

	Hours Standard.	Hours Actual.	Number of Men.	Efficiency.
Dec., 1904	828.8	1,375.8	11	60.2
Jan., 1905	2,011.17	3,613.9	21	55.6
Feb., "	2,780.9	4,636.1	30	60.
Mch., "	4,350.2	7,418.8	50	58.6
Apr., "	7,649.6	12,748.3	77	60.
After two years.				
Mar., 1907	36,695.2	40,997.3	225	89.5
Apr., "	60,314.9	64,028.6	297	94.2

A Comparison of Actual Costs with Standard Costs as to Every Operation.

This is exceedingly easy. Each job is assigned to each man on a work card which states the standard time. The man notes his own actual time which in the aggregate must check with his clock time.

Actual Record of Work Done by No. 02510, Topeka Shops, 8 Consecutive Days in March, 1907.

Dept. No. 2.

Machine Rate, $0.33. Machine 1460. Dept. Charge 85%. Man Rate, $0.32.

Sched. No	Operation.	Charge.	Std. Hours.	Actual Hours.
....	Turn ¾" off one counter-balance, on one pair of wheels	S. 036835	4.1	4 1
T-84	Turn tires on two pair drivers	Eng. 1006	4.4	4.4
J-25	Turn three pair journals	Eng. 1006	7.5	6.7
J-26	Turn one pair journals	Eng. 1001	2.3	2.6
T-63	Turn tires on three pair of drivers	Eng. 1001	12.0	12.0
....	Stamp three pair wheels	Eng. 1006	0.6	0.6
J-25	Turn two pair journals	Eng. 1001	5.0	4.6
H-177	Face one hub	Eng. 1001	0.5	0.5
....	Turn counterbalance on one pair of wheels	S. O. 36835	3.7	3.7
J 24	Turn one pair journals	Eng. 0166	2.2	2.2
....	Stamp three pair wheels	Eng. 1001	0.6	0.6
....	Make out tire report	Shop Exp.	1.0	1.0
J-21	Turn three pair journals	Eng. 176	6.6	6.1
M-7	Clean machine	Shop Expense	0.2	0.2
....	Stamp two pair wheels	Eng. 0160	0.4	0.4
T-184	Turn tires on two pair of drivers	Eng. 0166	4.4	4.0
J-25	Turn one pair journals	Eng. 1114	2.5	2.2
H-177	Face six hubs	Eng. 1144	3.0	2.4
T-63	Turn tires on one pair drivers	Eng. 1144	4.0	3.4
H-177	Face one (1) hub	Eng. 176	0.5	0.5
J 25	Turn three pair journals	Eng. 1000	7.5	6.6

J-25	Turn journals on one pair drivers	Eng.	257	2.5	2.6
H-177	Face two (2) hubs	Eng.	1000	1.0	0.8
J-24	Turn journals on two pair drivers	Eng.	257	4.4	4.0
H-177	Face two (2) hubs	Eng.	515	1.0	1.0
J-25	Turn one pair journals	Eng.	515	2.5	2.1
....	Face one pair drivers	Eng.	515	0.7	0.7
				85.1	80.0

Efficiency, 106.4%.

This man is a most upright and conscientious worker, so absolutely fair and reliable that his word and opinion is accepted without question as to corrections of a standardized time. He has asked to have standard times shortened when on a series of trials he found them too easy, and on the other hand his opinion that a time was not long enough would be given fullest weight.

The clock time for the eight days, 80 hours, checks up the time actually taken for the jobs, so there is neither object nor inducement to any man to report false times. Take, for instance, the record of the seventh day:

Standard Times.	Actual Times.
7.5	6.6
2.5	2.6
1.0	0.8
11.0	10.0

Assuming a man wholly unreliable, or who omits to report any of the actual times, it cannot make any difference as to the efficiency report, since that is based on the clock cards and by making incorrect reports he has deprived himself of the help that would be his due to locate and overcome a difficulty for which he may not be personally responsible. For every man and for his whole time a record of this kind is potentially available since it is contained on his work cards.

The efficiency of each man is tabulated each month. Four actual cards are given as samples:

SANTA FE EFFICIENCY RECORD.

John Doe. No. 23.

Machinist. Dept. 2.

Month.	Rate.	Total Time. Standard.	Actual.	Per Cent. Effic'y.	Bonus.	Amount Wages.	Amount Bonus.	Total Earnings.
Jan., '07	$3.20	281.8	261.0	108.0	28.0	$83.52	$23.38	$106.90
Feb., '07		247.6	226.0	109.6	29.5	72.32	21.33	93.65
Mar., '07		283.7	260.5	108.8	29.0	83.36	24.17	107.53
Apr., '07		283.9	258.0	110.0	30.0	82.56	24.77	107.33

An absolutely steady worker.

SANTA FE EFFICIENCY RECORD.

H. J. Doe. No. 44.

Machinist. Dept. 1.

Month.	Rate.	Total Time. Standard	Actual.	Per Cent. Effic'y.	Bonus.	Amount Wages.	Amount Bonus.	Total Earnings.
Jan., '07	$3.40	174.0	158.0	110.2	30.0	$53.72	$16.12	$69.84
Feb., '07		261.4	220.0	117.3	37.5	75.48	28.30	103.78
Mar., '07		322.8	250.0	129.0	49.0	85.00	41.65	126.65
Apr., '07		322.6	233.0	138.5	58.5	79.22	46.34	125.56

A man stimulated by bonus to faster and faster work.

SANTA FE EFFICIENCY RECORD.

M. T. Doe. No. 32.

Machinist. Dept. 1.

Month.	Rate.	Total Time. Standard.	Actual.	Per Cent. Effic'y.	Bonus.	Amount Wages.	Amount Bonus.	Total Earnings.
Jan., '07	$3.00	102.7	95.0	108.1	2.8	$28.50	$7.98	$36.48
Feb., '07		147.3	210.0	70.1	.22	63.00	.13	63.13
Mar., '07		93.7	157.5	59.5	....	47.25	....	47.25
Apr., '07		130.7	227.0	57.6	....	68.10	....	68.10
			Quit.					

A man, capable, but unsteady and indifferent, who finally quit of his own accord.

SANTA FE EFFICIENCY RECORD.

Chas. Doe. No. 11.

Machinist. Dept. 1.

Month.	Rate.	Total Time. Standard.	Actual.	Per Cent. Effic'y.	Bonus.	Amount Wages.	Amount Bonus.	Total Earnings.
Jan., '07	$3.00	82.6	99.0	83.4	5.25	$29.70	$1.56	$31.26
Feb., '07		182.4	221.0	82.5	4.62	66.30	3.06	69.36
Mar., '07		203.7	253.5	80.4	3.52	76.05	2.68	78.73
Apr., '07		77.7	109.0	71.3	.46	32.70	.15	32.85

A man worth standard wages and very little more.

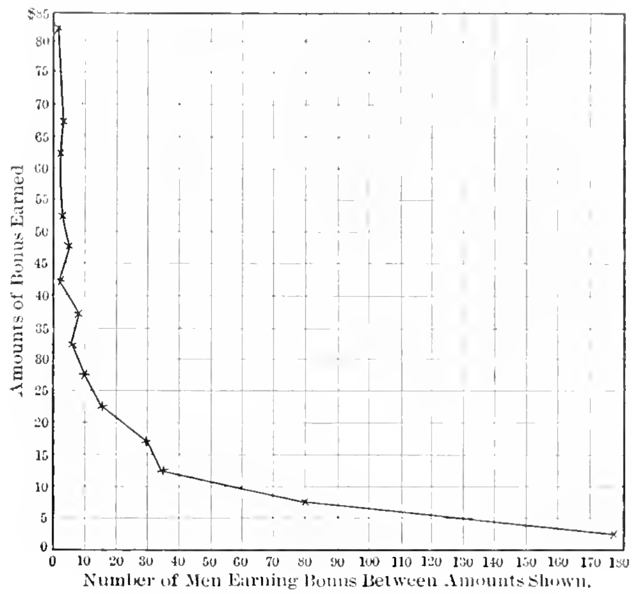
The efficiency reward is on a sliding scale. It begins at 67 per cent. and increases rapidly according to a table carried out to tenths of a per cent.

Per Cent. Efficiency.	Bonus Above Standard Wages.
65	0.00
70	0.22
75	1.31
80	3.27
85	6.17
90	9.91
95	14.53
100	20.00
110	30.00
120	40.00
150	70.00
200	120.00

THE REWARD TO FOREMEN.

The efficiency of the foreman depends on the efficiency of all the men under him. If all the men average 100 per cent. the foreman receives 20 per cent. increase on his own wages. Under some other foreman the extra earnings of the men might be in the aggregate more, but not average as well, if some men were very good and others very poor. Such a foreman would earn less increase, so it is to the advantage of a foreman to bring up his whole force evenly.

The curve of bonus earnings is curiously close to a hyperbola. There are many men who earn low bonus, there are a



BONUS EARNINGS, TOPEKA SHOP, APRIL, 1907.

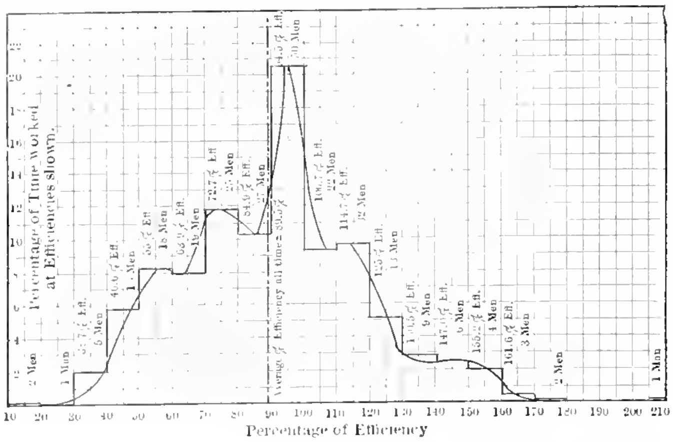
few men who earn high bonus, and the higher the bonus the lower the unit cost.

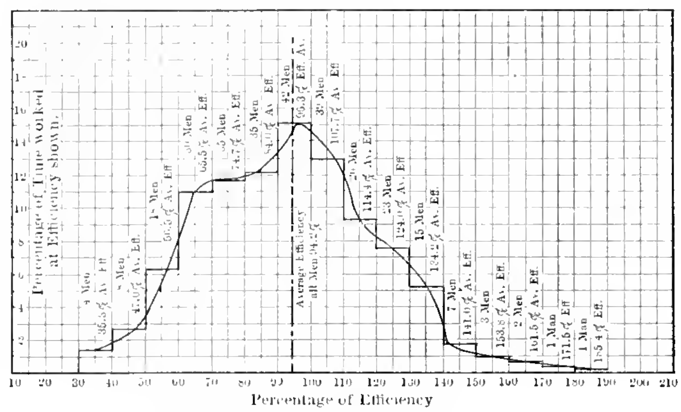
SHOP EFFICIENCY AS A WHOLE.

Shop efficiency as a whole is determined by the average efficiency of all the workers. The two diagrams show the same shop in two successive months and the improvement in the second month is largely due to the lessons in the diagram of the first month. It is plain that the shop is improving when the average efficiency line moves to the right, that it is retrograding when it moves to the left. It can be made to move to the right by finding out what the matter is with the men whose average efficiency is low, and all workers with an efficiency under 70 per cent. should be investigated. The record is there not only as to monthly efficiency, as a whole, but as to every single job done in the month. It often happens that efficiency falls through no fault of the worker, as when a steel casting is so hard as to make normal work impossible. In very marked cases of this kind temporary schedules are put into effect to suit the peculiar and exceptional occurrence.

The diagrams show that while even in the best shop the greater part of the workers are normally good, there are a few geniuses far in advance and some stragglers far in the rear. It would be utterly futile, even if the management was so inclined, to demand from the average man the results given by the geniuses. The only proper way is to reward these exceptional men suitably and fully for their special skill. The very poor men are but a small part of the whole, only 4 per cent. The attempt to base wages on the efficiency of this 4 per cent. is as iniquitous and ridiculous as at the other end to offer normal wages for the extraordinary output of the geniuses. Men who continuously cannot or will not do a fair day's work for normal pay are out of place in a modern shop and should seek some other occupation.

Because the better men are rewarded for their own greater skill, because the check of every operation permits the correction of any condition which is a detriment to the worker, because it also permits infallibly the detection of incompetent and listless men, it is perfectly possible, month by month, to move





MARCH, 1907—EFFICIENCY OF EMPLOYEES IN TOPEKA SHOPS—APRIL, 1907.

the efficiency line forward. Competitors will not know enough to pay as much for the best men, who therefore remain as an asset, growing yearly more valuable; competitors will not know enough to correct bad conditions or promptly to eliminate incompetent men, so they will continue to run shops with an efficiency of 60 per cent. or less, when 100 per cent. to 120 per cent. is attainable.

The Use of Standard Costs in Accounting.

Since every job is standardized it necessarily has a standard cost. How ridiculous it would be for a railroad company to attempt to vary its ticket prices on account of accidental delays or extraordinary expenses, as for a wreck.

It is not less ridiculous to attempt to follow into costs accidental variations of shop operation. If a fast worker is on a job one day and a slow worker on the same job the next day, both have varied from standard, but the selling price of what they have made nas not changed.

Variations from standard costs are accidents of shop operation and are to be taken care of, not in detail but as a whole, by a factor added in the office. In the examples of the two months, the efficiency of labor was 89.5 in March. Actual labor costs were therefore 11 7 per cent. higher than standard. This 11.7 per cent. could have been applied to each item of the output in the following month. In April the actual costs were 6.2 above standard, so for May 6.2 per cent. could have been added to the direct labor part. The discrepancies should, however, be averaged for at least twelve months, and if this was done it would be found that the fluctuation in office factor to be thrown forward with the succeeding month would not vary as much as 1 per cent. from month to month.

The Effects of this System of Shop Management.

(1) To increase output enormously without adding to shop equipment or space.

(2) To reduce unit costs as much as 30 per cent. or more.

(3) To increase the pay of the best men as much as 30 per cent. on the average.

(4) To hold permanently the best men.

(5) To know accurately the cost of every item before work is begun on it.

Relations of costs and efficiencies in a shop working 10,000 hours a day, average wages $0.36, average machine rate $0.40 per hour, average burden $0.24 per hour.

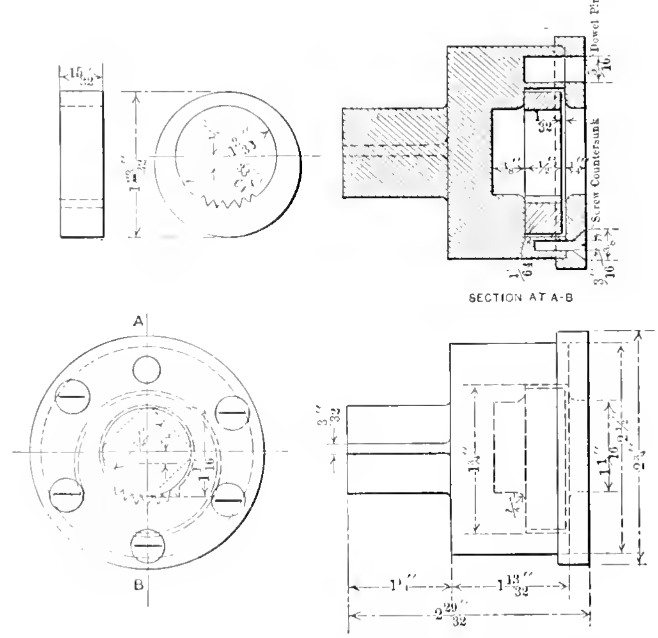
Efficiency	Increase in Wages.	Total Cost Per Day.	Reduction in Unit Cost.	Inceased Output.
60	0.	10,000	0.	——
70	7.92	10,007.92	14 24	16.7
80	117 72	10 117.72	24 12.	33.3
90	356.76	10,356.76	30 96	50.
100	720.	10,720	35.68	66.7
110	1080.	11,080	39.56	83.3
120	1414.	11,414	43.00	100.

A shop, as above, increasing its efficiency from 60 to 120 per cent., not impossible of realization, increases wages 44.4 per cent., decreases unit costs 43 per cent. and doubles the output

The system is equally applicable to railroad operations as a whole, *i. e.*, the mileage of engines and cars and tonnage movement It is, in fact, on the Santa Fe now being adapted to determine the efficiency of each engine, exactly as in the Topeka shop it has been perfected to determine the efficieney of each man. Even as men in average shops work with less than 60 per cent. efficiency, so also do engines work with less than the 60 per cent. efficiency. What was done with the men in the shop can be done with engines.

STAY BOLT CLUTCH.

A simple but very efficient stay bolt clutch is shown on the accompanying drawing. This was devised by Mr. A. W. Martin, tool room foreman and apprentice shop instructor at the Bright-



wood shops of the Big-Four. All of the parts are of soft steel, case hardened, except the clutch, which is of hardened tool steel. The clutch is eccentric and the greater the pressure exerted in turning the stay bolt the tighter it will grip; when the pressure is released the clutch readily loosens.

Flexibility of Motor Car Engine.—Motor car No. 8 was equipped with a 200 horse-power gasoline engine, designed and built at the Union Pacific shops, at Omaha. The engine was designed particularly for motor car service, and the hope for a flexible control engine has been fully realized, the engine being able to start and accelerate the car from zero to sixty miles an hour simply by varying the speed of the engine. If the car attains a speed of fifty miles an hour, and it is desired to run slower, it can be accomplished by simply closing down the throttle, reducing the consumption of gasoline, and therefore saving fuel.—*Mr. W. R. McKeen, Jr., at the New York Railroad Club, Apr., 1907.*

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED IN ORDER OF TOTAL WEIGHTS

FREIGHT LOCOMOTIVES OF THE CONSOLIDATION OR 2-8-0 TYPE

TYPE.	CONSOLIDATION								
Name of road	P. B. & L. E.	D. & H.	L. S. & M. S.	L. S. & M. S.	N. Y. C.	P. R. R.	Wabash	N. P.	B. & O
Road number or class	150	1,011	5,962	G-46	G-4	2,762	....	....	2,503
Builder	Pitts.	Amer.	Amer.	Amer.	Amer.	Amer.	Bald.	Amer.	Amer.
When built	1900	1906	1906	1903	1903	1905	1906	1901	1905
Simple or compound	Simple	Simple	Simple	Simple	Tan comp.	Simple	Simple	Tan. comp.	Simple
Tractive effort, lbs	63,800	49,690	45,677	46,500	46,600	45,700	42,600	44,900	41,100
Weight, total, lbs	250,300	246,500	232,500	230,000	225,000	220,000	214,500	209,500	208,500
Weight on drivers, lbs	225,200	217,500	207,000	203,000	200,000	198,000	189,600	185,500	185,900
Weight on trucks, lbs	25,100	29,000	25,500	27,000	25,000	22,000	24,900	24,000	22,600
Weight, tender loaded, lbs	141,000	152,400	149,600	148,000	137,500	140,500	....	....	143,500
Wheel base, driving	15' 7"	17' 0"	17' 6"	17' 3"	15' 0"	17' 6"	15' 9"	15' 0"	16' 8"
Wheel base, engine	24' 4"	25' 11"	26' 5"	26' 5"	23' 7"	26' 5"	24' 6"	23' 8"	25' 7"
Wheel base, engine and tender	57' 11¾"	57' 7½"	60' 9½"	57' 9¾"	59' 1"	60' 3¾"	57' 10½"	52' 4½"	59' 8¼"
Diameter of drivers	54"	57"	63"	58"	51"	63"	58"	55"	60"
Cylinders, number	2	2	2	2	4	2	2	4	2
Cylinders, diameter and stroke	24" × 32"	23" × 30"	23" × 32"	23" × 30"	16" & 30" × 30"	23" × 32"	22" × 30"	15" & 28" × 34"	22" × 30"
Valve gear, type	Steph.	Wals	Wals.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.
Steam pressure, lbs	220	210	200	200	200	200	200	200	205
Boiler, type	Str	Wooten	Rad stay	W. T.	E. W. T	Str.	W. T.	E. W. T.	Str.
Boiler, smallest diameter	84"	83¾"	81⅞"	80"	77"	80"	77"	75"	74.5"
Boiler, height center	119¾"	113"	118¼"	119½"	111"	117"	....	111¼"	118"
Heating surface, tubes, sq. ft	3,564	3,716	3492.18	3,725	3,915	3,600	3,053	3450.4	2630.1
Heating surface, firebox, sq. ft	241	329.5	213.05	232	227	182	192	195.9	179.3
Heating surface, total, sq. ft	3,805	4045.5	3705.23	3,957	4,142	3,782	3,245	3646.3	2809.4
Heating surface, superheater, sq. ft	....	....	....	....	....	....	....	....	....
Grate area, sq. ft	36.8	99.85	56.5	55	58	55.4	50.4	52.3	56.24
Firebox, length	132"	126⅛"	108⅛"	108"	105⅛"	106"	108⅛"	100"	107⅝"
Firebox, width	40¼	114	75¼"	73¼"	75⅜"	75¼"	67¼"	75¼"	75¼"
Fuel, kind	Bit coal	Anth coal	Bit coal	Bit coal	Bit coal	Bit. coal	Bit. coal	Bit coal	Bit. coal
Tubes, number firetube	406	493	446	461	507	446	360	412	282
Tubes, number superheater	....	....	....	....	....	....	....	....	....
Tubes, diameter firetube	2¼"	2"	2"	2"	2"	2"	2¼"	2"	2¼"
Tubes, diameter, superheater	....	....	....	....	....	....	....	....	....
Tubes, length	15'	14' 6"	15'	15' 6½"	14' 9"	15' 4¾"	14' 6"	15'	15' 10"
Tender, coal capacity, tons	14	14	12	16	12	13½	....	10	15
Tender, water capacity, gals	7,500	7,800	7,500	7,500	7,000	7,000	8,000	5,500	7,000
Weight on drivers ÷ tractive effort	3.58	4.37	4.5	4.37	4.3	4.3	4.44	4.1	4.5
Weight, total ÷ tractive effort	3.95	4.97	5.0	4.95	4.85	4.8	5.	4.67	5.1
T. E. × diam. drivers ÷ total H. S.	900	700	775	650	575.	760.	760.	680.	875.
Total heat. surf ÷ grate area	103	40.5	65.8	72	71.	68.	64.	69.	50.
Firebox heat surf ÷ total H. S. %	6.34	8.12	5.75	5.85	5.5	4.82	5.9	5.4	6.35
Wgt. on drivers ÷ total heat. surf	59	53.5	55.8	51.2	48.5	52.	58.	51.	66.
Wgt. total ÷ total heat surf	65.8	60.8	62.5	58	54.5	58.	66.	59.	74.
Equated heating surface†	1161	1304.5	1116.05	1179.	1252.	1102.	992.	1085.9	839.3
Equated heat surf. ÷ grate area	31.7	13.1	19.8	21.4	21.5	20.	19.8	20.7	14.8
Trac eff × diam driv ÷ equat H S	2960	2160	2580	2300	1900.	2600.	2500.	2270.	2940.
Total H. S. ÷ superheating heat surf.	....	....	....	....	....	....	....	....	....
Cylinder volume, cu ft	16.75	14.4	15.3	14.4	13.3*	15.4	13.2	14.2*	13.2
Total heat. surf. ÷ cyl vol	258	280	242.	275.	310.	246.	246.	256.	213.
Equated heat surf ÷ cyl vol	69.5	90.5	72.2	82.	94.	71.8	75.	76.5	63.3
Sup. heat. surf. ÷ cyl. vol	....	....	....	....	....	....	....	....	....
Grate area ÷ cyl. vol	2.19	6.92	3.66	3.8	4.35	3.6	3.8	3.8	4.3
Reference in The American Engineer	1900 p. 211	1907 p. 22	1906 p. 283	1903 p. 415 1904 p. 11	1903 p. 174	1906 p. 73	....	....	1906 p. 31

TYPE.	CONSOLIDATION								
Name of road	Har. lines	C. S. N. O. & P.	P. R. R.	C. B. & Q.	M. St. P. & S. S. M.	W. P.	C. R. I. & P.	C. P. R.	C. of G.
Road number or class	C-187	....	H 6 B	D4	445	....	551)	M4	1,200
Builder	Bald.	Bald.	Bald.	Amer.	Amer.	Bald.	Bald.	Shops	Bald.
When built	1905	1907	1905	1903	1905	1906	1906	1904-6	1907
Simple or compound	Simple	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple
Tractive effort, lbs	43,299	43,300	42,200	42,500	37,300	44,100	39,600	36,800	34,000
Weight, total, lbs	208,000	207,000	204,470	202,600	201,500	201,330	198,600	186,200	163,390
Weight on drivers, lbs	187,000	182,000	181,170	179,200	174,000	186,330	177,300	163,700	143,290
Weight on trucks, lbs	21,000	27,000	23,300	23,400	27,500	15,000	21,300	22,525	20,100
Weight, tender loaded, lbs	135,050	148,000	143,000	150,200	116,900	....	140,300	121,400	119,610
Wheel base, driving	15' 8"	16' 0"	16' 3"	15' 8"	17' 0"	15' 8"	17' 0"	15' 10"	16' 0"
Wheel base, engine	24' 4"	24' 4"	24' 9"	24' 6"	25' 11"	24' 4"	26' 0"	24' 4½"	24' 3½"
Wheel base, engine and tender	55' 11¾"	56' 3"	58' 1½"	69' 1¼"	55' 8¼"	57' 11½"	58' 0"	53' 4¼"	53' 9"
Diameter of drivers	57"	57"	56"	57"	63"	57"	63"	57"	56"
Cylinders, number	2	2	2	2	2	2	2	2	2
Cylinders, diameter and stroke	22" × 30"	22" × 30"	22" × 28"	22" × 28"	23" & 35" × 34"	22" × 30"	23" × 30"	21" × 28"	20" × 28"
Valve gear, type	Steph.	Wals.	Wals.	Steph.	Steph	Steph.	Wals.	Steph.	Steph.
Steam pressure, lbs	200	200	205	210	210	200	185	200	200
Boiler, type	Str.	Str.	Belp.	Str.	E. W. T	Str	E. W. T	E. W. T.	W. T.
Boiler, smallest diameter	80"	78"	71"	79½"	67⅜"	80"	71"	69"	61"
Boiler, height center	114"	115½"	108¾"	115"	115"	....	117"	111½"	105⅝"
Heating surface, tubes, sq. ft	3,226	2,939	2675.9	3511.56	2407.5	2,927	2,427	2,216	2069.3
Heating surface, firebox, sq. ft	177	183	166.5	221.77	158	214	168	165	140.
Heating surface, total, sq. ft	3,403	3,122	2842.4	3733.33	2565.5	3,141	2,595	2,381	2209.3
Heating surface, superheater, sq. ft	....	....	....	....	261.4	....	....	375	....
Grate area, sq. ft	49.5	51	49.11	54.2	46.8	33.6	50	43	44
Firebox, length	108"	108"	107"	108⅜"	96⅛"	121"	107"	96"	96⅛"
Firebox, width	66"	68"	66"	72"	70¼"	40"	67¼"	65¼"	66"
Fuel, kind	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit coal	Bit coal	Bit coal	Bit coal
Tubes, number firetube	413	386	373	450	224	390	340	244	283
Tubes, number superheater	....	....	....	....	40	....	....	22	....
Tubes, diameter firetube	2"	2"	2"	2"	2"	2"	2"	2"	2"
Tubes, diameter, superheater	....	....	....	....	3½"	....	....	5"	....
Tubes, length	15'	14' 6½"	13' 8½"	15'	15' 9"	14' 5"	15' 6"	14' 1⅜"	14' 8"
Tender, coal capacity, tons	14	12	13½	14	10	14	12	10	8
Tender, water capacity, gals	7,000	7,500	7,000	8,000	6,000	8,000	7,000	5,000	6,000
Weight on drivers ÷ tractive effort	4.3	4.2	4.3	4.2	4.65	4.2	4.5	4.4	4.2
Weight, total ÷ tractive effort	4.8	4.76	4.8	4.8	5.4	4.55	5	5.1	4.8
T. E. × diam. drivers ÷ total H. S.	725.	790.	830.	650.	830.	800.	965	800	860.
Total heat. surf ÷ grate area	69.	61.	58.	69.	55.	93.	52.	55.	50.
Firebox heat surf ÷ total H. S. %	5.2	5.85	5.9	5.9	6.15	6.8	6.5	6.9	6.3
Wgt. on drivers ÷ total heat. surf	55	58.2	63.5	48	48.7	59.5	68.	69.5	65.
Wgt. total ÷ total heat surf	61.	66.	72.	54.	56.5	64.	77.	78.	74.
Equated heating surface†	1012.	953.	891.5	1129.77	764	984.	785	755.	680.
Equated heat surf. ÷ grate area	20.5	18.8	18.2	20.5	16.3	29.4	15.7	17.5	15.5
Trac eff × diam driv ÷ equat H S	2440.	2590.	2650.	2150.	3070	2550	3180	2780.	2800.
Total H. S. ÷ superheating heat surf.	....	....	....	....	9.85	....	....	6.35	....
Cylinder volume, cu ft	13.2	13.2	12.4	12.4	11.4*	13.2	14.4	11.2	10.2
Total heat. surf. ÷ cyl vol	259	236.5	229.	302.	312.	238.	180	213.	217.
Equated heat surf ÷ cyl vol	76.5	72.	72.	91.	67.	74.5	54.3	67.	66.5
Sup. heat. surf. ÷ cyl. vol	....	....	....	....	23.	....	....	33.3	....
Grate area ÷ cyl. vol	3.75	3.87	3.95	4.4	4.1	2.55	3.48	3.8	4.3
Reference in The American Engineer	1905 p. 154	1907 p. 194	1906 p. 231	1903 p. 48	1905 p. 150	....	1907 p. 147	1906 p. 165	1907 p. 31

* Equivalent simple cylinders. † = Tube heat surf. ÷ √length tubes + firebox heat surf

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

FREIGHT LOCOMOTIVES OF OTHER TYPES THAN THE CONSOLIDATION

TYPE	MALLET				SANTA FE 2-10-2		DECAPOD 2-10-0		MIKADO 2-8-2		TEN WHEEL 4-6-0		MOGUL 2-6-0	0-10-0	0-8-0		0-6-0	
Name of road	Erie*	G N	B & O	G N*	P S & N*	A T & S F	B R & P*	A T & S F	N P	N. P	C & E I	C. P. R	Vandalia	L S & M S	C & O	P & L E	P R R	B & O
Road number or class	....	L-1	2,400	....	98	900	....	987	W	1,608	289	D-10	V-F. 5a	M	8	253	B-6	D-23
Builder	Amer	Bald	Amer	Bald	Bald	Bald.	Amer	Bald	Amer	Amer.	Bald.	C. P. R	Amer	Amer	Amer	Amer	P. R. R	Amer
When built	1907	1906	1904	1907	1907	1903	1907	1902	1905	1906	1905	1905-6	1907	1905	1903	1906	1904	1906
Simple or compound	Comp	Comp	Comp	Comp	Simple	Tan. comp	Simple	Tan. comp	Tan. comp	Simple	Bal. comp	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	98,000	71,600	70,000	57,760	60,000	62,800	55,350	62,500	45,000	46,630	31,000	33,300	31,360	55,300	41,000	44,100	36,100	29,740
Weight, total, lbs	410,000	355,000	334,500	288,000	288,000	287,240	275,000	266,500	271,000	261,000	191,060	190,000	187,000	270,000	171,175	178,200	170,000	161,080
Weight on drivers, lbs	410,000	316,000	334,500	250,000	235,000	234,580	245,000	237,000	207,000	205,000	145,260	141,000	159,300	270,000	171,175	178,200	170,000	161,080
Weight on trucks, lbs	......	19,000	....	18,000	......	23,420	......	29,500	30,300	26,000	45,800	49,000	27,700	......	......	......	......	......
Weight on trailer, lbs	......	20,000	......	20,000	......	29,240	......	......	33,700	30,000	......	......	......	......	......	......	......	......
Weight, tender loaded, lbs	163,000	148,000	143,000	152,000	162,000	158,500	162,000	132,000	148,500	177,800	120,000	123,700	144,800	......	121,160	121,300	132,500	85,000
Wheel base, driving	14' 3"	10' 0"	......	9' 10"	19' 9"	19' 9"	19' 0"	20' 4"	16' 6"	16' 6"	13' 6"	14' 10"	14' 9"	19' 0"	13' 7½"	12' 0"	11' 6"	11' 0"
Wheel base, engine	39' 2"	44' 10"	30' 8"	43' 7"	35' 11"	35' 11"	25' 4"	29' 10"	34' 9"	34' 9"	27' 7"	26' 1"	23' 10"	19' 0"	13' 7½"	12' 0"	11' 6"	11' 0"
Wheel base, engine and tender	72' 2"	73' 2¼"	64' 7"	72' 0¼"	67' 4½"	66' 0"	65' 3½"	59' 6"	63' 1"	63' 1"	55' 8"	54' 6¾"	56' 10¼"	54' 5½"	45' 8"	46' 2¼"	48' 3¼"	40' 9½"
Diameter of drivers	51"	55"	56"	55"	57"	57"	52"	57"	63"	63"	62"	63"	63"	52"	51"	50"	56"	52"
Cylinders, number	4	4	4	4	2	4	2	4	4	2	4	2	2	2	2	2	2	2
Cylinders, diameter	25" & 39"	21½ & 33"	20" & 32"	20" & 31"	28"	19" & 32"	24"	19" & 32"	19" & 30"	24"	15½" & 26"	21"	21"	24"	21"	21"	22"	19"
Cylinders, stroke	28"	32"	32"	30"	32"	32"	28"	32"	30"	30"	26"	28"	28"	28"	28"	30"	24"	28"
Valve gear, type	Wals	Wals	Wals	Wals	Wals	Steph.	Wals	Steph	Steph	Wals	Steph	Steph.	Wals.	Wals	Steph	Steph.	Steph.	Steph.
Steam pressure, lbs	215	200	235	210	160	225	210	210	200	200	225	200	200	210	200	200	205	180
Boiler, type	Conical	Belp	Str	Belp.	E. W. T	W. T	Conical	W. T	E. W. T	E. W. T	W. T.	E. W. T.	Str.	W. T	W. T.	Str.	Belp	Wooten
Boiler, smallest diameter	84"	81"	81"	72"	78¾"	78¾"	80"	78¾"	78¾"	78¾"	64"	70⅝"	76⅝"	80⅛"	67"	80"	67¼"	70"
Boiler, height center	......	120"	120"	116"	118"	118"	116"	118"	118"	118"	109"	113½"	115½"	115"	112½"	108½"	108"	105"
Heating surface, tubes, sq. ft	5,760	5,473	5,380	3,708	4,586	4,587	3,280	5155.8	3,819	3,192	2933.7	2,233	2754.6	4422.6	2,573	2906	2343.	1476.67
Heating surface, firebox, sq. ft	348	230	220	198	210	209	255.5	234.2	209	245†	160.7	180	180.4	197	164	206	152.1	172.84
Heating surface, total, sq. ft	6,108	5,703	5,600	3,906	4,796	4,796	3535.5	5390	4,028	3,437	3094.4	2,413	2935	4619.6	2,737	3112	2495.1	1649.5
Heating surface, superheater sq. ft	......	......	......	......	762	......	......	......	......	......	......	378	......	......	......	......	......	......
Grate area, sq. ft	100	78	72.2	53.4	58.5	58.5	55.5	58.5	43.5	43.5	46.69	49.5	52.	55.4	38.8	33.3	41.25	73.33
Firebox, length	126"	117"	108¼"	116¼"	108"	108	108"	108"	96"	96"	101⅞"	102¼"	108⅛"	108⅛"	80"	120"	90"	110"
Firebox, width	114"	96"	96¼"	66¼"	78"	78"	73¾"	78"	65¼"	65¼"	66"	69⅞"	69¼"	73¼"	70"	40"	66"	96"
Fuel, kind	Bit coal	Bit Coal	Bit Coal	Bit Coal	Bit. coal	Bit coal	Bit coal	Bit coal	Bit coal	Bit coal	Bit coal	Bit. coal	Bit. coal	Bit coal	Bit. coal	Bit coal	Bit coal	An coal
Tubes, number firetube	468	441	436	301	391	391	404	463	374	372	278	266	390	447	351	430	325	220
Tubes, number superheater	......	......	......	......	......	......	......	......	......	......	......	22	......	......	......	......	......	......
Tubes, diameter, firetube	2¼"	2¼"	2¼"	2¼"	2¼"	2¼"	2"	2¼"	2"	2"	2¼"	2"	2"	2"	2"	2"	2"	2¼"
Tubes, diameter, superheater	......	......	......	......	......	......	......	......	......	......	......	5"	......	......	......	......	......	......
Tubes, length	21' 0"	21' 0"	20' 10¾"	21' 9"	20' 0"	20' 0"	15' 6"	19' 0"	19' 6"	16' 6"	18' 0"	14' 2⅞"	13' 5⅞"	19' 0"	14' 0"	13' 0"	13' 10¼"	11' 6"
Tender, coal capacity, tons	16	13	16	13	14	14	14	11	12	12	12	10	13	12	7	10	11	6
Tender, water capacity, gals	8,500	8,000	7,000	8,000	8,500	8,500	9,000	7,000	8,000	10,000	6,000	5,000	7,500	8,000	6,000	7,000	5,500	4,000
Weight on drivers ÷ tractive effort	4.18	4.4	4.75	4.34	3.91	3.75	4.47	3.82	4.6	4.38	4.67	4.24	5.05	4.86	4.15	4.04	4.7	5.4
Weight, total ÷ tractive effort	4.18	4.95	4.75	5.00	4.8	4.56	5.12	4.26	6.0	5.6	6.15	5.7	5.9	4.86	4.15	4.04	4.7	5.4
T. E. × diam. drivers ÷ total H. S.	820	690	700.	813.	712.	747.	812	661.	705	855	620.	870.	675	625.	763.	710.	810.	940.
Total heat. surf. ÷ grate area	61	73	77.3	73	81.8	81.8	63.3	92	92.5	78.8	66	48.6	56.4	83.	70.5	94	60.3	22.5
Firebox heat. surf. ÷ total H. S. %	5.7	4.13	3.92	5.05	4.38	4.34	7.2	4.33	5.18	7.12	5.18	7.42	6.14	4.25	5.98	*6.6	6.08	10.5
Wgt. on drivers ÷ total heat. surf.	61.	55.2	59.5	63.9	49.	48.8	70.1	43.8	51.1	59.6	46.7	58.5	54.1	58.3	62.3	57.1	68	97.3
Wgt. total ÷ total heat. surf.	61.	62.	59.5	73.8	60.	59.8	80.3	49.3	66.9	75.5	61.6	78.5	66.5	58.3	62.3	57.1	68.	97.3
Equated heating surface	1598.	1425.	1400.	1008.	1240.	1239.	1088.5	1419.2	1073	1030.	850.7	770.	930.4	1212.	851.	1011.	782.1	607.84
Equated heat. surf. ÷ grate area	15.98	18.3	19.4	18.9	21.25	21.2	19.6	24.3	24.7	23.7	18.2	15.5	18.	21.8	21.9	†30.4	19.	8.25
Trac. eff. × diam. driv. ÷ equat. H. S.	3130	2770	2800.	3170.	2760.	2880.	2650.	2520.	2650.	2850.	2260.	2730.	2120	2380.	2450.	2180.	2570.	2550.
Total H. S. ÷ surperheating heat. surf	......	......	......	......	6.3	......	......	......	......	......	......	6.39	......	......	......	......	......	......
Cylinder volume, cu. ft.	24	20.75	19.	17.1	22.82	17.9	14.6	19.4	15.8	15.8	8.93	11.2	11.2	14.7	11.2	12.	10.5	9.2
Total heat. surf. ÷ cyl. vol.	255.	275.	295.	229.	210.	268.	243.	278.	255.	218.	346.	215.	263.	314.	245.	260.	238.	179.
Equated heat. surf. ÷ cyl. vol	66.8	68.8	73.5	59.	54.1	69.	74.5	74.1	68.	65.2	95.5	68.7	83.	82.5	76.2	84.	74.3	65.5
Sup. heat. surf. ÷ cyl. vol	......	......	......	......	33.4	......	......	......	......	......	......	33.8	......	......	......	......	......	......
Grate area ÷ cyl. vol	4.17	3.75	3.85	3.14	2.57	3.28	3.81	3.	2.75	2.76	5.2	4.43	4.65	3.78	3.48	2.77	3.95	7.95
Reference in THE AMERICAN ENGINEER	1906 p. 429	1906 p. 371	1904 p. 237, 262	This issue.	1907 p. 88	'03 p. 372, 398 1904 p. 176	1907 p. 133	1902 p. 192	1905 p. 367	1906 p. 392	1905 p. 97	1906 p. 165	1907 p. 27	1905 p. 330	1904 p. 184	1906 p. 346	1904 p. 384	1906 p. 257

* Builders' weights. † Combustion chamber 3' long.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF THE PACIFIC (4-6-2) AND PRAIRIE (2-6-2) TYPES

TYPE.	PACIFIC.													PRAIRIE.				
Name of road	N P	O R & N	Erie	B & O	C B. & Q.	Mex. Nat.	A.T. & S.F.	Har. lines	C & A.	M C.	So. Ry.	C. P R	C. R. I & P.	A T. & S F	L. S & M. S	C. B & Q	N. P.	G. N
Road number or class	2,175	194	2,511	P	S1.	420	1,251	P 141	602	K-80	1,238	G1a	841	1800	4,724	R5	2,378	J1
Builder	Amer	Bald.	Amer.	Amer.	....	Bald	Bald.	Bald	Bald.	Amer.	Bald.	C. P. R	Amer.	Bald.	Amer	Amer	Amer.	Bald.
When built	1906	1905	1905	1906	1906	1907	1905	1905	1904	1904	1906	1906	1905	1906	1906	1906	1906	1906
Simple or compound	Comp	Comp.	Simple	Simple	Simple	Comp.	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple
Tractive effort, lbs	30,340	28,300	30,300	35,020	31,100	35,066	32,800	29,920	29,900	28,500	34,940	28,000	31,000	37,800	27,850	35,060	33,300	37,560
Weight, total, lbs	240,000	231,500	230,500	229,500	228,000	227,340	226,700	222,000	221,500	221,000	219,500	212,000	212,000	248,200	233,000	216,000	209,500	209,000
Weight on drivers, lbs	157,000	143,600	149,000	150,500	150,000	147,040	151,900	141,000	135,110	140,500	138,460	139,000	143,500	174,700	165,200	152,000	152,000	151,000
Weight on trucks, lbs	53,000	43,400	41,000	40,500	42,000	....	35,800	37,000	40,500	42,500	39,740	39,000	34,500	31,300	26,000	25,600	....	21,000
Weight on trailer, lbs	30,000	41,300	40,500	38,500	36,000	....	39,000	44,000	45,490	38,000	41,300	34,000	34,000	42,200	41,800	38,400	....	37,000
Weight, tender loaded, lbs	141,350	159,000	163,000	147,000	148,200	142,660	....	162,200	166,600	122,600	136,800	122,700	150,000	175,000	159,900	148,200	139,500	151,000
Wheel base, driving	12′ 0″	13′ 4″	13′ 0″	13′ 2″	12′ 10″	12′ 0″	13′ 8″	13′ 4″	13′ 4″	13′ 0″	12′ 6″	13′ 0″	12′ 4″	13′ 8″	14′ 0″	13′ 4½″	11′ 0″	13′ 0″
Wheel base, engine	33′ 5″	33′ 7″	33′ 8″	34′ 3½″	32′ 9″	33′ 11″	34′ 0″	33′ 4″	33′ 4″	33′ 7½″	31′ 4½″	33′ 7″	32′ 0″	33′ 9″	34′ 3″	30′ 8½″	28′ 11″	30′ 9″
Wheel base, engine and tender	62′ 10″	64′ 1½″	65′ 1″	66′ 3¾″	64′ 3¼″	62′ 11″	66′ 1½″	63′ 10½″	62′ 5½″	60′ 5″	64′ 5⅞″	59′ 3¾″	61′ 1″	65′ 0″	62′ 5½″	62′ 2¾″	57′ 3½″	63′ 8″
Diameter of drivers	69″	77″	74″	74″	74″	67″	73″	77″	77″	75″	72½″	75″	69″	69″	79″	69″	63″	69″
Cylinders, number	4	4	2	2	2	4	4	2	2	2	2	2	2	4	2	2	2	2
Cylinders, diameter	16½″ & 27½″	17″ & 28″	22½″	22″	22″	17″ & 28″	17″ & 28″	22″	22″	22″	22″	21″	22″	17½″ & 29″	21½″	22″	21″	22″
Cylinders, stroke	26″	28″	26″	28″	28″	28″	28″	28″	28″	26″	28″	28″	26″	28″	28″	28″	28″	30″
Valve gear, type	Wals.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Wals	Wals.	Steph.	Steph	Wals
Steam pressure, lbs	220	200	200	225	200	220	220	200	20	200	220	200	200	225	200	210	200	210
Boiler, type	E. W. T.	Str.	Str.	Str.	W. T.	W. T	W. T.	Str.	Str.	Str.	Str.	E. W. T.	E. W. T.	E. W. T.	E. W. T.	W. T.	E. W. T	Belp.
Boiler, smallest diameter	72¼″	70″	74⅝″	72″	70″	70″	70″	70″	70″	72¼″	70″	66″	68⅜″	76″	70″	70″	72¼″	72″
Boiler, height center	115″	....	113½″	112″	109¾″	109″	....	113″	113″	113″	109″	112″*	113½″	115″	114″	107⅜″	115″	108″
Heating surface, tubes, sq ft	2667.	2874	3131	3234.6	3732.	3527.	3402.2	2874	874	3690.6	3683.5	2777.	3174.5	3803	3678.	3375	2105	3277
Heating surface, firebox, sq. ft.	241.8	179	195.	179.4	200.	186	192.8	174	179.	207.1	195	180.	179.41	217.	227.	200.	235.	210
Heating surface, total sq. ft.	2908.8	3053.	3326.	3414	3932.	3713.	3595.	3048.	3053.	3897.7	3878.5	2957	3353.91	4020.	3905	3575	2340	3487
Heating surface, superheater, sq ft	....	....	765.	....	....	....	....	....	....	....	....	526.	....	....	....	....	....	....
Grate area, sq ft	43.5	49.5	56.5	56.24	54.	52.1	53.	49.5	49.5	50.23	54.25	45.6	44.8	53.8	55	54	43.5	53.15
Firebox, length	96″	108″	108⅛″	108⅛″	105⅛″	113½″	108″	108″	108.	96⅛″	108⅛″	94⅛″	96⅛″	107⅛″	108⅛″	108⅛″	96″	116
Firebox, width	65¼″	66″	75¼″	75¼″	72¼″	66¼″	71¼″	66″	66.	75¼″	72¼″	69⅞″	67¼″	71¼″	73¼″	72¼″	65¼″	66
Fuel, kind	Bit coal	Bit. coal	Bit coal	Bit. coal	Bit. coal	Bit coal	Oil	Bit coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit coal
Tubes, number firetube	306	245	195	276	303	301	290	245	245.	354	314	193	328	342	322	303	306	301
Tubes, number superheater	....	....	32	....	....	....	....	....	....	....	....	22	....	....	....	....	....	....
Tubes, diameter, firetube	2″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2¼″	2¼″	2″	2¼″	2¼″	2¼″	2″	2¼″
Tubes, diameter superheater	....	....	5″	....	....	....	....	....	....	....	....	5″	....	....	....	....	....	....
Tubes, length	16′ 9″	20′ 0″	20′ 0″	20′ 0″	21′ 0″	20′ 0″	20′ 0″	20′ 0″	20′ 0″	20′ 0″	20′ 0″	19′ 6″	18′ 7″	18′ 10 5/16″	19′ 6″	19′ 0″	13′ 3″	15′ 6″
Tender, coal capacity, tons	12	10	16	15	13	12	3,300	12	15	10	12½	10	13	14	15	13	12	13
Tender, water capacity, gals	7,000	9,000	8,500	7,000	8,000	7,500	8,500	9,000	8,400	6,000	7,500	5,000	7,500	9,000	8,000	8,000	7,000	8,000
Weight on drivers ÷ tractive effort	5.2	5.05	4.95	4.3	4.8	4.2	4.6	4.7	4.5	4.9	4.	4.95	4.6	4.6	4.4	4.3	4.6	4
Weight, total ÷ tractive effort	7.9	8.2	7.7	6.6	7.3	6.5	6.9	7.4	7.4	7.8	6.3	7.6	6.8	6.6	8.3	6.2	6.3	5.6
T. E. × diam. drivers ÷ total H. S.	720	713.	660	760	585	632	666.	755.	750.	555	653.	685.	640.	650.	565	677	900.	746
Total heat. surf. ÷ grate area	67.	61.7	58.7	60.5	71.3	71.2	68.	61.5	61.5	77.	71.5	65.	75.	74.	71	64.8	53.8	65.
Firebox heat. surf ÷ total H. S. %	8.3	5.85	5.85	5.23	4.85	5.	5.35	5.70	5.85	5.3	5.00	6.1	5.3	5.4	5.8	5.34	10.1	6.0
Wgt. on drivers ÷ total heat. surf.	53.8	47.	45.	44	38.	37.4	42.	46.5	44	36.	35.7	47.	42.5	43.5	42.	42.5	65	43.5
Wgt. total ÷ total heat surf.	82.5	75.	69.5	66.5	58.	61.1	63.	73.	72.	57.	56.5	71.5	63.	62.	61	60.7	89.5	60.
Equated heating surface	893.8	820.	895	901.4	1013	876.	952.8	816	821.	1032.1	1018.	807	916.4	1097.	1059.	974	813.	972
Equated heat. surf. ÷ grate area	20.5	16.6	15.8	16.1	18.7	16.8	18.	16.5	16.6	20.5	18.7	17.7	20.5	20.5	19.2	18.1	18.7	18
Trac. eff. × diam. driv. ÷ equat. H. S.	2340.	2660.	2450.	2880.	2280.	2690.	2520.	2830	2800.	2075.	2500.	2610.	2330	2400	2080	2480.	2580	2680.
Total H. S. ÷ superheating heat. surf	....	....	4.35	....	....	....	....	....	....	....	....	5.6	....	....	....	....	....	....
Cylinder volume, cu. ft.	9.9*	11.6*	12.	12.3	12.3	11.6*	11.6*	12.3	12.3	11.4	12.3	11.2	11.4	12.1*	11.7	12.3	11.2	13.2
Total heat. surf. ÷ cyl. vol.	294.	265.	277.	278	318.	330.	310.	248	249.	342.	316.	265.	295	334.	335.	290.	209	265.
Equated heat. surf. ÷ cyl. vol.	90.5	70.5	74.5	73	82.	75.5	81.5	66.2	66.8	90.5	82.5	72.	80.2	89.5	90.	79	72.6	73.5
Sup. heat. surf. ÷ cyl. vol.	....	....	63.5	....	....	....	....	....	....	....	....	48	....	....	....	....	....	....
Grate area ÷ cyl. vol.	4.3	4.28	4.7	4.56	4.39	4.54	4.55	4	4.	4.39	4.41	4.06	3.93	4.43	4.68	4.46	3.89	4.03
Reference in THE AMERICAN ENGINEER	1906	1905	1905	1906	1906	1907	1905	1905	1904	1904	1906	1906	1905	1906	1906	1906	1906	1906
	p. 411	p. 246	p. 172	p. 257	p. 300	p. 70	p. 454	p. 154	p. 133	p. 347	p. 145	p. 165	p. 252	p. 435	p. 204	p. 300	p. 392	p. 365

*—Equivalent simple cylinders.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF TYPES OTHER THAN THE PACIFIC AND PRAIRIE

TYPE	ATLANTIC (4-4-2)							
Name of road	U P	Erie	N. Y. C.	P. R. R.	N. Y. C.	C. B. & Q.	Har Lines	C. R. I. & P.
Road number or class	21	537	1	2,760	11	P3	A-81	1,019
Builder	Baldwin	Amer	Bald	Amer	Amer	Bald.	Bald	Amer
When built	1906	1905	1905	1905	1904	1904	1905	1905
Simple or compound	Comp	Comp.	Comp.	Comp.	Comp	Comp	Simple	Simple
Tractive effort, lbs.	21,281	23,860	24,200	23,300	24,000	21,400	23,560	24,700
Weight, total, lbs.	209,000	206,000	204,500	200,500	200,000	196,600	196,000	191,300
Weight on drivers, lbs.	110,000	115,000	110,000	117,200	110,000	101,200	105,000	107,100
Weight on trucks, lbs.	53,000	52,000	52,400	52,500	50,000	54,200	45,000	42,400
Weight on trailer, lbs.	46,000	39,000	42,100	30,000	40,000	41,200	46,000	40,800
Weight tender loaded, lbs.	162,200	162,800	124,000	132,500	124,000	120,400	162,200	144,000
Wheel base, driving	7' 0''	7' 0''	7' 0''	7' 5''	7' 0''	7' 3''	7' 0''	7' 0''
Wheel base, engine	27' 10''	28' 9''	30' 9''	31' 11''	27' 9''	30' 2''	27' 7''	27' 5½''
Wheel base, engine and tender	58' 5''	60' 9''	56' 8''	61' 4''	53' 8''	57' 6¼''	58' 2''	57' 2''
Diameter of drivers	81''	78''	79''	80''	79''	78''	81''	73''
Cylinders, number	4	4	4	4	4	4	2	2
Cylinders, diameter	16'' & 27''	15½ & 26''	15½ & 26''	16'' & 27''	15½ & 26''	15'' & 25''	20''	21''
Cylinders, stroke	28''	26''	26''	26''	26''	26''	28''	26''
Valve gear, type	Wals	Steph	Steph	Steph	Steph	Steph	Steph	Steph
Steam pressure, lbs.	200	220	220	205	220	210	200	185
Boiler, type	Str	E. W. T.	Str	Belp	Str	E. W. T.	Str	Str
Boiler, smallest diameter	70''	70¼''	70⅝''	65⅝''	70⅝''	64''	70''	72''
Boiler, height center	113''	111½''	111''	109''	111''	108½''	113''	108''
Heating surface, tubes, sq. ft.	2475	3453.6	3465	2680.2	3267	3050.5	2475	2227.6
Heating surface, firebox, sq. ft.	180	181.1	198	181.1	198	155.5	174	161.8
Heating surface, total, sq. ft.	2655	3634.7	3663.	2861.6	3465	3206.	2649	2389.4
Heating surface, superheater, sq. ft.								338
Grate area, sq. ft.	49.5	56.5	50.3	55.5	50.3	44.1	49.5	44.8
Firebox, length	108''	108¼''	96¼''	111''	96¼''	96¼''	108''	96''
Firebox, width	66''	75¼''	75¼''	72''	75¼''	66¼''	66''	67¼''
Fuel, kind	Bit coal	Bit coal	Bit coal	Bit coal	Bit coal	Bit coal	Bit coal	Bit coal
Tubes, number firetube	297	388	318	315	390	264	297	173
Tubes, number superheater								54
Tubes, diameter, firetube	2''	2''	2¼''	2''	2''	2¼''	2''	2''
Tubes, diameter, superheater								3½''
Tubes, length	16' 0''	17' 0''	18' 6''	16' 3''	16' 0''	19' 0''	16' 0''	16' 0''
Tender, coal capacity, tons	10	16	10	12½	10	12	10	12
Tender, water capacity, gals.	9,000	8,500	6,000	5,500	6,000	6,000	9,000	7,000
Weight on drivers ÷ tractive effort	4.53	4.82	4.55	5	4.58	4.7	4.45	4.2
Weight total ÷ tractive effort	8.6	8.63	8.45	8.6	8.35	9.2	8.35	7.8
T. E. × diam. drivers ÷ total H. S.	740	513	520	650	548.	518.8	717	754.
Total heat. surf. ÷ grate area	53.8	64.3	73	51.6	69	73.	53.6	53.3
Firebox heat. surf. ÷ total H. S. %	6.8	5	5.4	9.37	5.7	4.85	6.6	6.75
Wgt. on drivers ÷ total heat. surf.	41.5	31.7	30.	41	31.8	31.5	39.6	44.8
Wgt. total ÷ total heat. surf.	78.9	56.8	56.	70.	58	61.3	74	80.
Equated heating surface	798.	1018	1004	845.4	1013	855.5	792.	718.8
Equated heat. surf. ÷ grate area	16.1	17.9	20.	15.2	20.1	19.4	16.	16.
Trac. eff. × diam. driv. ÷ equat. H. S.	2470.	1835	1900.	2210	1875	1950.	2400.	2510
Total H. S. ÷ superheating heat. surf.								7.08
Cylinder volume, cu. ft.	10.2†	8.93†	8.93†	10.2†	8.93†	8.3†	10.2	10.4
Total heat. surf. ÷ cyl. vol.	262	408	409.	280	386.	387.	260.7	230.
Equated heat. surf. ÷ cyl. vol.	78.	114.	113.	83.	113.	103.	77.5	69
Sup. heat. surf. ÷ cyl. vol.								32.5
Grate area ÷ cyl. vol.	4.83	6.27	5.6	5.42	5.6	5.3	4.85	4.3
Reference in THE AMERICAN ENGINEER	1906 p. 308	1905 p. 287	1905 p. 109	1906 p. 73	1904 p. 166	1904 p. 212	1905 p. 154	1905 p. 329

TYPE	ATLANTIC (4-4-2)			TEN WHEEL (4-6-0)				AMERICAN (4-4-0)		
Name of road	G. W. (Eng.)	P. R. R.	D. L. & W.	N. Y. C.	C. & N. W.	Belgium	London & S. W.	C. R. R. of N. J.	D. L. & W.	L. S. & M. S.
Road number or class	40	2,512	1,012	2,099			330	852	955	Pony
Builder	Gt. West.	Soc. Als.	Amer	Amer	Amer	Soc. Anon.	L. & S. W.	Amer.	Amer	L. S. & M. S.
When built	1906	1904	1905	1905	1907	1906	1905	1905	1905	1906
Simple or compound	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs.	25,086	19,530	35,100	31,000	30,900	31,500	25,300	23,120	23,710	15,700
Weight, total, lbs.	166,880	164,000	201,000	194,500	179,500	179,300	163,520	161,300	151,200	126,600
Weight on drivers, lbs.	88,704	87,850	154,000	148,000	135,500	115,500	114,360	111,300	100,000	85,100
Weight on trucks, lbs.	40,096	41,250	47,000	46,500	44,000	63,800	48,160	50,000	51,200	41,500
Weight on trailer, lbs.	38,080	34,900								
Weight tender loaded, lbs.	89,600	132,500	120,000	143,500	139,500		99,564	122,200	110,000	105,200
Wheel base, driving	7' 0''	7' ½''	14' 4''	15' 10''	14' 10''	14' 2''	13' 4''	8' 3''	8' 6''	9' 0''
Wheel base, engine	27' 9''	28' 6 5/16''	25' 6''	26' 10½''	25' 10''	38' 8½''	26' 7''	23' 1½''	24' 5''	25' 1¾''
Wheel base, engine and tender	53' 6¼''	59' 5''	54' ¼''	59' 2''	57' 9''		53' 2''	49' 2''	51' ⅝''	48' 4¾''
Diameter of drivers	80½''	80 5/16''	69''	69''	63''	78''	72''	69''	69''	63''
Cylinders, number	4	4	2	2	2	4	4	2	2	4
Cylinders, diameter	14¼''	14⅛ & 23⅝''	21½''	22''	21''	17½''	16''	19''	20''	12½''
Cylinders, stroke	26''	25 3/16''	26''	26''	26''	24''	24''	26''	26''	20''
Valve gear, type	Steph	Wals	Steph	Steph	Wals.	Wals	Both	Steph.	Steph.	Wals.
Steam pressure, lbs.	225	227½	215	200	200	205	175	200	185	180
Boiler, type	Belp	Belp	Str	W. T.	E. W. T.	Str	Str.	W. T.	Str	W. T.
Boiler, smallest diameter	58¾''	59⅝''	71⅝''	70⅝''	66¾''	65''	67⅜''	62¼''	61 3/16''	50''
Boiler, height center	98''	106 5/16''	116½''	115''		110¼''	108''	113''		78''
Heating surface, tubes, sq. ft.	1988.65	2435.7	3156.3	3124	2808.4	1494.84	2210.	1838.1	1947.9	1326
Heating surface, firebox, sq. ft.	154.26	181.1	221.7	202.7	150.8	181.7	517 **	167.6	190.8	140
Heating surface, total, sq. ft.	2142.91	2616.8	3378	3326.7	2959.2	1676.54	2727.	2005.7	2138.7	1466.
Heating surface, superheater, sq. ft.						419.27				
Grate area, sq. ft.	27.07	33.9	91.8	51.93	46.27	32.4	31.5	81.6	87.54	21
Firebox, length	98½''	119⅞''	126⅛''	105⅛''	102⅛''	118.67''	114''	122⅛''	126 3/16''	96''
Firebox, width	38½''	40''	108¾''	75¼''	65¾''	40.55''	45''	96¼''	100''	31''
Fuel, kind	Bit coal	Bit coal	Anth. coal	Bit. coal	Bit coal	Bit coal	Bit coal	Anth coal	Anth. coal	Bit coal
Tubes, number firetube	250	139*	398	400	337	108	340	280	280	187
Tubes, number superheater						25				
Tubes, diameter, firetube	2'	2 3/16''	2''	2''	2''	2''	1¾''	2''	2''	2''
Tubes, diameter, superheater						5''				
Tubes, length	15' 2 3/16''	14' 5¼''	15' 3''	14' 11''	16' 0''	13' 1½''	14' 4½''	12' 6''	13' 4¼''	13' 6½''
Tender, coal capacity, tons		12½	10	12	10	6½	4.5	12	10	10
Tender, water capacity, gals.	3,500	5,500	6,000	7,000	7,500	4,400	4,000	5,000	5,000	4,300
Weight on drivers ÷ tractive effort	3.7	3.5	4.38	4.77	4.38	3.66	4.5	4.8	4.22	5.4
Weight total ÷ tractive effort	6.64	8.4	5.72	6.27	5.80	5.7	6.5	6.95	6.4	8.1
T. E. × diam. drivers ÷ total H. S.	913.	600.	717	647.	655.	1470.	660.	800	765.	670
Total heat. surf. ÷ grate area	78.8	77.5	35.6	60.5	64	51.7	86.5	24.7	24.4	69.5
Firebox heat. surf. ÷ total H. S. %	7.2	6.9	6.6	6.1	5.10	12.2	18.6	8.4	8.9	9.5
Wgt. on drivers ÷ total heat. surf.	41.4	33.6	45.6	44.5	45.75	68.9	42.	55.3	46.8	58.
Wgt. total ÷ total heat. surf.	78	62.6	59.8	58.7	60.50	107.	60.	80.5	71.	86.5
Equated heating surface	664.26	821.1	1028.7	1010.7	852.8	594.7	1099	687.6	722.8	501
Equated heat. surf. ÷ grate area	24.5	24.2	10.9	18.4	18.4	18.4	34.8	8.4	8.3	23.8
Trac. eff. × diam. driv. ÷ equat. H. S.	3040	1910.	2350.	2130.	2280	4150.	1665.	2320.	2270.	1980.
Total H. S. ÷ superheating heat. surf.						4.00				
Cylinder volume, cu. ft.	9.6	7.15†	10.9	11.4	10.4	12.8	11.2	8.6	9.5	5.7
Total heat. surf. ÷ cyl. vol.	223.	367.	311.	292.	287.	131.	244.	233	224.	257.
Equated heat. surf. ÷ cyl. vol.	69	115.	94	88.	82.	46.3	98.	80.	76.	87.5
Sup. heat. surf. ÷ cyl. vol.						32.8				
Grate area ÷ cyl. vol.	2.82	4.72	8.68	4.8	4.45	2.53	2.81	9.5	9.2	3.68
Reference in THE AMERICAN ENGINEER	1907 p. 57	1904 p. 203	1905 p. 407	1906 p. 59	This issue	1906 p. 220	1907 p. 183			1906 p. 293

* Serve tubes. † Equivalent simple cylinders. ** Drummond firebox.

REAL APPRENTICESHIP.

By G. M. BASFORD.*

Probably no subject which has been continuously before the railroads of this country for many years has received more interested attention during the last few years than methods of recruiting the service by apprenticeship.

While some important items of organization and management as well as engineering construction become fads and are overdone, there is no danger whatever of such a result in connection with apprenticeship. This is true chiefly because the conditions surrounding recruiting have been so long neglected as to promise improvement for any kind of effort. This is equivalent to saying that the apprentice situation cannot be made worse.

A very general movement—especially in the eastern section of the country—in the direction of trade schools indicates the wide interest in the general subject on the part of both manufacturers and educators. While this movement suffers somewhat from a lack of definiteness it seems impossible that anything but great good can come from it. If communities engage in trade school development the whole country will be benefited, but the benefit will, for a long time, be diffused and indefinite. No matter what the trade school development may be, there will yet remain a vast problem of the most specific kind in supplying large organizations with the leadership talent of which they stand so greatly in need. Trade schools will not fill this want, because what is needed for this development is the training of recruits in these large organizations in such a way as to keep the young men, during this training, under the control of the influences which conduct the organizations themselves.

The large industrial establishments and large railroads share in the problem of providing the men of the future; and these men cannot be trained for them by outside influence—no matter how good this influence may be or how well directed. This means that large organizations must conduct their own training schools; and, that this fact is forcing itself upon the attention of those who are carrying the heaviest responsibilities of management, is clearly indicated by the interest now expressed in apprenticeship plans and methods by some of the largest organizations of the country.

The prediction was made several years ago to the effect that before long a wave of apprentice education would pass from one end of this country to the other. This has already occurred, but we are to have another and larger wave. To those who are to be responsible for the future development in this direction, the work which has already been accomplished is exceedingly important; and no one need now feel, in establishing an apprenticeship system to meet modern conditions, that he is tilling new ground or that he lacks sufficient and satisfactory precedent.

Perhaps a few principles which seem most likely to lead to complete success may be appropriately noted here.

First of these is to really return, in effect, to the fundamentals of the ancient apprenticeship, not of a generation ago, but perhaps three or four generations ago, when industrial units were so small as to render it possible for the master to give his personal attention to the apprentice. When these units became large enough to introduce a journeyman helper for the master, our present troubles began. We need to get back to the time when there were no helpers, but the blacksmith, himself, trained the boy and looked after his moral and intellectual as well as mechanical training. Of course, to-day, the master cannot do this, because of the change which numbers have brought; but the master to-day may delegate, to a well qualified man, these most important duties. The very fact that men qualified to train boys are so difficult to obtain illustrates the distance which we have drifted from the path of rectitude. Our first principle, then, is to select the best man to be found for this executive work, the most important part of which is to see that the boys are taught trades in accordance with the promises which are so freely given them in the indentures. Having selected the man to teach the trades, he must be given authority which will permit of success; and, if some slight inconveniences occur, they must be met, for it is certainly as important to produce men as it is produce machinery.

Another principle is mental training which, to insure complete success, must be parallel and simultaneous with the manual training in order that the boy may understand his work—that he may know his materials, understand his methods, and that he may know the reasons for what he does. For this, night schools will not suffice, and it seems fair to say that no recruiting system can approach the ideal which does not provide this mental training by taking the school to the boy; taking it in working hours and compelling his attention to it as being as vital a part of his apprenticeship as the trade itself. This requires another sort of substitute for the master of years ago in the form of one who is prepared to contribute to the mental training the equivalent to the manual training of the shop instructor.

It is important that the apprentice should come into contact with the real problem of the shop and that he should work as nearly as possible upon the same basis as the workmen, knowing that the product which he contributes is part of the general product of the plant. He should at once come into contact with the commercial questions of cost and incidentally with the problem of management in the organization, so that he may see where the workman and employer fit into the general scheme. In the mental training the same idea appears. This offers no field for the lover of "pure mathematics," but it offers a wonderful field for the man with practical ideas who understands the apprentice mind and knows the questions which are constantly arising with respect to the work of the shop. Mechanical drawing offers the readiest educational medium, and the development of this subject will lead to a clear view of the entire educational scheme. The brain and the hand must be trained simultaneously.

While other fundamental principles may be enumerated, but one more will be mentioned, which, embodied in the form of a question, is: What is to become of the apprentices when through with their terms? All that need be said about this is that until the organization is such that a wide-awake, ambitious apprentice may profitably grow into it, with a view of spending his life there, the apprenticeship effort should not be inaugurated. Probably the most vital element in the success of any apprentice scheme is that the organization should be such as to be worthy of receiving well prepared apprentices. The organization may need the first attention. How many of our railroads or our industrial establishments approach the ideal in this respect?

* Assistant to the President, American Locomotive Company.

STORAGE OF LOCOMOTIVE COAL IN CARS.—The importance of providing storage room so as to cut down the delay of cars as much as possible is ordinarily underestimated. One day's storage of locomotive coal in cars on the Pennsylvania system costs more than $300,000 a year, figuring that the cars are worth one dollar a day each. An expenditure of $4,000,000 would be justified to avoid holding two days' supply of coal in cars, considering that the structure costs 15 per cent. of the original cost for interest, depreciation and maintenance. Figuring 40 tons to the car, storage in cars costs 2½ cents per ton per day, and an expense of $61 a ton is justifiable to avoid it. Ordinarily, storage in the bin is much cheaper than in cars, yet the usual practice is to keep from one to five days' supply stored in cars at the different plants.—*Report of Committee, Amer. Ry. Eng. & M. of W. Assoc.*

WATER-TUBE LOCOMOTIVE BOILERS POSSIBLE.—The compound locomotive has shown its ability to develop more power per ton of weight than the single expansion engine, and its increasing use in the future may be expected. The balanced type is the most promising for high speed service, while for slow and heavy freight service the Mallet type seems particularly suitable. Radical changes in design, such as the introduction of the water-tube boiler, for example, are by no means beyond the limits of possibility; while superheated steam may play an important part in the solution of the transportation problem.—*Paul T. Warner before the Franklin Institute.*

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Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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M. M. AND M. C. B. ASSOCIATIONS.

The Master Mechanics' Association will meet at Atlantic City, N. J., June 12, 13 and 14, and the Master Car Builders' Association will meet June 17, 18 and 19. The meetings of both associations will be held in the Sun Parlor on the Steel Pier.

CO-OPERATION

A division may be said to be well managed, as far as its power is concerned, when the following four features, which to a certain extent are co-related and dependent upon each other, are nicely adjusted. These are, a reasonable mileage per engine failure; a reasonable cost for repairs per mile run; a reasonable per cent of power out of service at a fixed hour (omitting engines held twenty-four hours or less), and a reasonable mileage between general repairs. Any attempt to make a showing on one of these items without reference to the other three will probably show on careful investigation that it has been made at the expense of the others. The master mechanic, in order to be really successful, must secure the co-operation of the division superintendent to assist in keeping these four features balanced. Unless these two officers do co-operate and assist each other good results cannot be expected. Probably no other one thing can do quite so much to reduce the net earnings as friction or ill will between these two departments and vice versa. The problem of operating a railroad is so great that it requires several different departments, but it must not be lost sight of that they are all working for one purpose and that they have a common treasury.

THE SUPERHEATER IN LOCOMOTIVE PRACTICE.

The article by Mr. William Schmidt in this number, descriptive of a Swiss locomotive fitted with his latest design of superheater, is of special interest as illustrating the tendency abroad toward a higher degree of superheat. Mr. Schmidt is probably the leading authority on this subject among foreign engineers and the alterations in his well-known smoke tube type of superheater, for the purpose of holding the steam longer in contact with the hot gases and thus giving it a higher temperature, indicate his ideas on the subject. He claims that unless the steam is sufficiently superheated to prevent *all* the cylinder condensation the full benefits of superheating are not obtained. As condensation depends largely on the area of cylinder surface and the temperature or pressure at exhaust, it is easily seen that with large cylinders working at a short cut-off this must necessarily be considerably higher than with smaller cylinders and a later cut-off. Conversely this means that highly superheated steam permits the use of larger cylinders and much shorter working cut-off. This point is well illustrated by the locomotive described.

Granting that the full benefits of superheating cannot be obtained unless all condensation is prevented, still it is reasonable to expect that a proportional benefit can be secured by a lower degree of superheat, which partially prevents or reduces condensation or at least guarantees dry steam at the cylinders with foaming boilers, and it is for this purpose that a design of superheater has recently appeared in this country and is now being applied to a number of locomotives.

ALL-STEEL PASSENGER SERVICE EQUIPMENT.

The need of stronger and non-combustible passenger equipment is becoming more and more recognized and it is apparently only a question of time when cars which meet certain requirements in this connection will be demanded by national legislation. The development of the all-steel freight car and the satisfactory service which it has given on roads where it has been used in large numbers, together with the fact that the all-steel passenger cars which have been in service in the New York Subway for the past two years, have proved very satisfactory, would indicate that there is no reason why the steel

passenger coaches cannot be designed for heavy service on steam roads which would be equally advantageous.

For the past six months we have presented detailed descriptions of all-steel coaches, which are being placed in service, at the rate of one a month. In designing these cars the mistakes in the introduction of all-steel freight equipment should be avoided, thus facilitating their introduction and saving the railroad managements much useless trouble and expense. It is of vital importance that before the railroads introduce this new equipment, the designs be carefully considered with a view to securing the advantages resulting from extensive interchangeability and standardization. We have been fortunate in securing a series of articles on this subject, compiled jointly by Messrs. Chas. F. Barba and Marvin Singer, both of whom have had special opportunities for making a thorough study of the development of all-steel freight car equipment, and of what has thus far been accomplished in developing designs for passenger equipment. The first of these articles is presented in this issue.

* * * * *

The placing of an order for 200 all-steel 70-ft. passenger coaches by the Pennsylvania Railroad is particularly significant. The size of the order for an entirely new and comparatively untried equipment would seem to indicate that, after a most careful study of present conditions and future probabilities, this company has concluded that the steel passenger train is the correct solution for many of the passenger traffic problems and proposes to put its convictions into practice at the earliest possible moment. It also makes the design adopted for these cars, details of which are given in this issue, of special interest.

THE MOTIVE-POWER DEPARTMENT PROBLEM.

A railroad will spend several thousand dollars for a machine tool which will increase the output of a certain class of work, or do it more economically. Special appliances are placed on locomotives at a considerable cost, either to increase their capacity or improve their efficiency. This is all very well and should be encouraged. There are, however, other features, productive of greater economies and higher efficiency for the same expenditure, which are often overlooked and the importance of which is not generally realized.

Suppose the new machine tool does the work for one-half of what it cost with the old methods, being careful in making these comparisons to include all surcharges. Even though this saving was made on the most important tool in the shop it would be but a very small percentage on the total cost of shop operation and yet we find men in the most important positions in the motive power department devoting a considerable part of their time to problems of just about this kind or type, whether it be in the shop or on the road, instead of tackling some of the bigger problems which are possibly not quite so apparent, but which if solved will produce much greater and more far-reaching results.

* * * * *

You know, in a general way, that you have men in your organization who are less efficient than others on the same class of work, but have you ever made an attempt to determine exactly the comparative efficiency of your men and to improve or cut off the less efficient men? The results accomplished at the Topeka shops of the Santa Fe, described by Mr. Harrington Emerson on page 221 of this issue, are startling. In two years the average efficiency of the men in the shop was increased from 60 to 94½ per cent. and the work is now only well started. The method of determining the exact efficiency of each man in the organization has only been in operation for a short time and the lessons which were learned from the figures for March, 1907, were such as to make it possible to increase the average efficiency of the men from 89.4 to 94.5 per cent. in the following month. The importance of these figures becomes more readily apparent when we learn that the efficiency of the average railroad shop, or shop of any kind, based on the above measure of efficiency, is probably as low as 50 per cent.

Surely something is wrong with our methods and very great improvements are possible when the difference between the efficiency of two men in the shop is as great as 500 or 600 per cent. and where by a careful and systematic effort it is possible to improve the average efficiency of the men in a shop 50 per cent. in two years.

* * * * *

The method of accurately determining the efficiency of the roundhouse as a whole and of each employee in it would appear to be very much more difficult than for a repair shop, in fact would seem almost out of the question. The problem has, however, been successfully solved on the Santa Fe as is indicated in the article on "Roundhouse Betterment Work," by Mr. J. F. Whiteford, on page 216 of this issue. The effect of men working in groups, or alone, the method of determining the amount of bonus due each man and of determining and improving the efficiency of each worker and of the roundhouse as a whole should be studied carefully not only by those who are interested in roundhouse work, but also by those interested in the labor question at large.

* * * * *

Mr. Hasting's article on the "Efficiency of the Worker and His Rate of Pay" is worthy of the most careful study, and while the reader may possibly not agree with his final conclusions they should receive thoughtful consideration. The advantages and disadvantages of the day rate, piece work and the bonus, or individual effort system, are clearly brought into contrast and Mr. Hasting's suggestion would seem to approach more closely to the ideal than any of these.

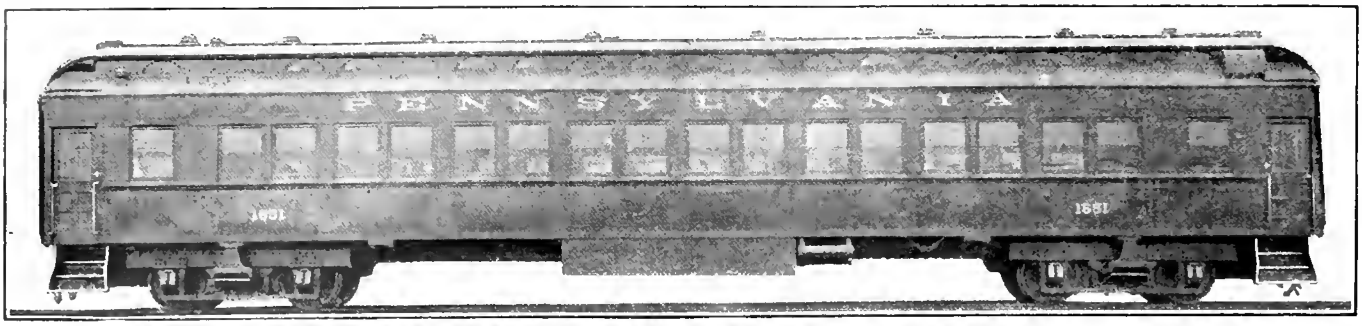
* * * * *

After all, the great problem confronting us to-day, whether on the railroad or in commercial organizations, is that of *men* and this is to be solved by not only perfecting the organization with a view to improving the efficiency of each employee, as suggested above, but also by providing a means for supplying skilled workmen, better educated and more thoroughly equipped for their work than are available at the present time and thus raising the standard of the employees throughout the organization. Manufacturing establishments are facing the same problem, and that they are beginning to realize its importance is indicated by the attention which is being given to the apprentice problem at the present time by several of the large manufacturers' associations, as well as by the larger individual establishments.

The Master Mechanics' Association has considered the apprentice problem in one form or another several times during the past, but it was not until two years ago, when Mr. G. M. Basford presented an individual paper on that subject, that its real importance seemed to be at all appreciated or that an adequate plan was suggested to solve the difficulty. As a direct result of Mr. Basford's paper and the resulting discussion several railroads have taken steps to improve the condition of their apprentices and to give them a more thorough training. The New York Central Lines have probably given the matter the most attention and have introduced upon a large scale an apprentice system which is based on rational and common sense lines.

Through the courtesy of Mr. J. F. Deems, general superintendent of motive power, and with the assistance of Mr. C. W. Cross, superintendent of apprentices, and his assistant, Mr. W. B. Russell, we were enabled to make a very careful study of the work which has thus far been accomplished. The more general features of the system are presented in an article in this issue and other articles, which will follow shortly, will consider the work in detail.

That the advantages which are thus far apparent are sufficient to justify the effort which is being made seems to be the opinion of the shop superintendents and foremen who are in touch with the work which the boys are doing. What the final returns at the end of a period of ten years will be it is, of course, impossible to predict accurately, but it does not seem unreasonable from present indications to prophesy that the efficiency of the workmen will be increased at least 25 per cent. and probably more, due to the introduction of the apprentice system.



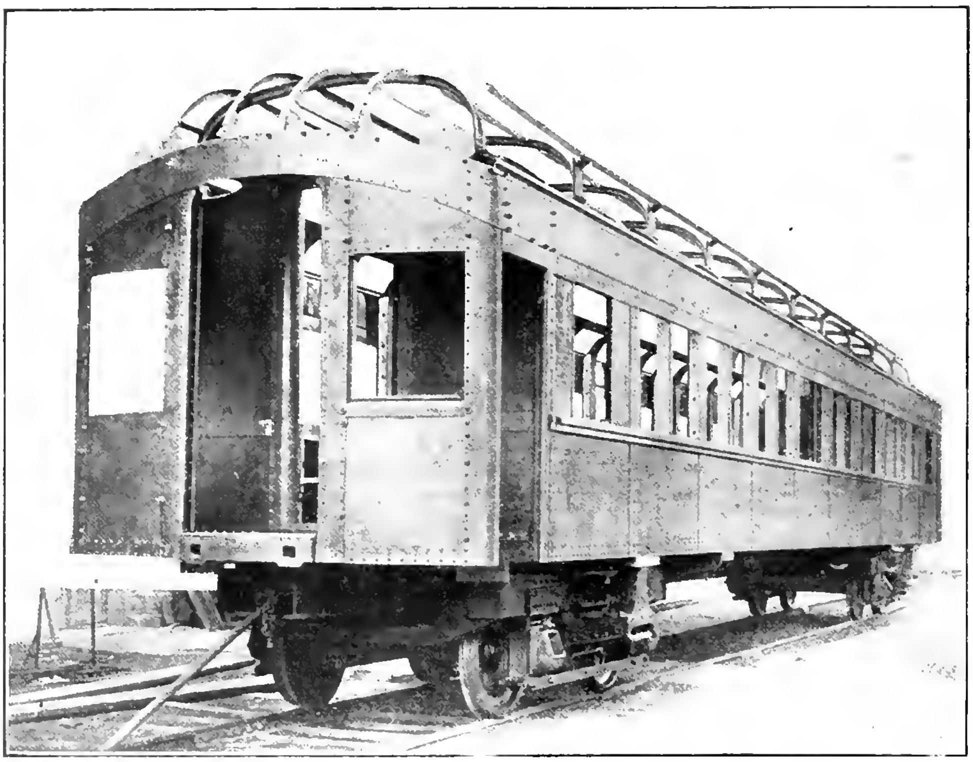
SEVENTY-FOOT STEEL PASSENGER COACH—PENNSYLVANIA RAILROAD.

ALL STEEL PASSENGER SERVICE CARS.

Pennsylvania Railroad.

The introduction of the all-steel car for passenger service on American railroads has been prophesied many times during the past few years and the past month has seen the first real move toward its fulfilment. This refers to the order for 200 passenger cars, placed by the Pennsylvania R. R. with the American Car & Foundry Company, the Pressed Steel Car Company and the Altoona car shops, the general design of which is illustrated herewith.

Our readers are acquainted with what has been done in the line of steel passenger car building in this country and know that several railroads have built cars of this type during the past few years, which have been placed in service and are now being given a practical trial. In addition to these strictly experimental cars there are also in operation comparatively large numbers of all-steel cars built for short haul traffic, such as subway, elevated and suburban work. These cars, while of course a big step in progress, do not present the difficulties in design that a full-sized modern passenger coach for a long haul service gives. Their service, however, and many of them have been in operation for over three years, has of course been of great value, and incidentally a great stimulus, in the design of the larger type, since they have conclusively proved that a steel car can be built which is perfectly satisfactory to both the traveling public and the railways.



VIEW SHOWING STEEL PASSENGER COACH PARTIALLY COMPLETED.

Reasons for Building Steel Cars.

The most important reasons why the construction of all-steel cars for regular service in through trains is desirable is very clearly explained and summed up in an article by Messrs. Barba and Singer* in this issue. Briefly these are: the increasingly high price of satisfactory timber, the public demand for fireproof cars and the desire to obtain the full benefit in the way of carrying capacity for the weight of the material in a non-collapsible car.

Action of the Pennsylvania.

These conditions have been recognized for some time by the Pennsylvania Railroad and several experimental steel cars have been built and put into service on its lines. The first of these was a 58-ft. passenger coach designed in 1904, and built in 1906, which has a steel underframe and a steel outside sheathing up to the roof. This car, however, contains about 1,500 lbs. of wood. Following this there was constructed a 60-ft. all-steel baggage car, which was completed last November, and a 70-ft. mail car,* which was finished in February of this year. There was also a car built by the American Car & Foundry Company for the Long Island Railroad,† which was operated over the Pennsylvania Lines for some time.

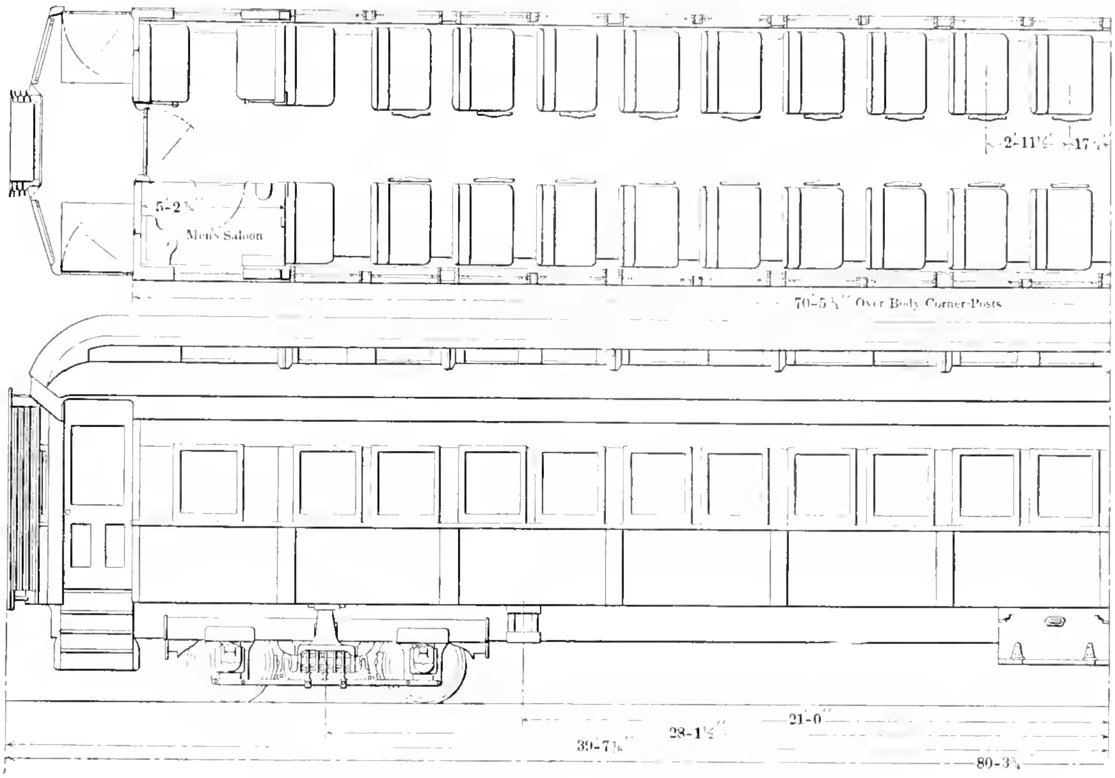
President Cassatt took a very active interest in this work. A committee composed of motive power and other officials of the Pennsylvania Railroad, was appointed to carefully investigate the whole subject, using the experience gained by the operation of these cars over their own lines, as well as of steel passenger cars on other roads, and the much longer and broader experience with steel freight cars, as a basis for recommending a design which should be adopted for a large order of cars. The cars which have now been ordered are of the design recommended by that committee. The recommendations included passenger service cars of all kinds for both through and suburban trains, having the general dimensions shown in the table below.

	Length.	Truck.	Capacity.	Weight.
Passenger coach	70' 5¾"	4 wheel	88 passengers	113,500 lbs.
Mail car	71' 4⅜"	6 "	....	128,000 "
Baggage and express car	60' 10⅜"	4 "	40,000 lbs.	91,000 "
Special baggage car.....	70' 0"	6 "	60,000 lbs.	120,000 "
Passenger-baggage	71' 1"	6 "	....	130,000 "
Dining	71' 11¾"	6 "	30 passengers	140,000 "
Suburban car	54' 4"	4 "	70 passengers	75,000 "

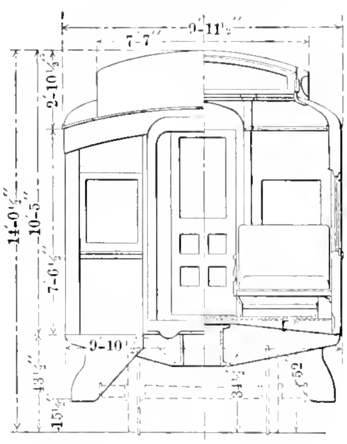
General Principles of Design.

All of these cars are based on the same general principles, which in brief are: that the car shall be absolutely fireproof;

* See American Engineer and Railroad Journal, April, 1907, p. 136.
† See American Engineer and Railroad Journal, Feb., 1907, p. 41.



PLAN AND ELEVATION OF SEVENTY-FOOT STEEL PASSENGER COACH.



that it shall be capable of withstanding, without any deformation or yielding, end shocks up to 400,000 lbs.; that the structure shall be such that the car body can be rolled down an embankment without collapsing; that the end structure shall be of sufficient strength to prevent one car sweeping the superstructure from another, and that the finished car shall be as light as the above conditions will permit.

In designing the framing for the cars there is offered a choice of two general types, one of which carries the whole load of the car and its lading by means of a heavy center sill, which is of sufficient strength in itself to resist very large buffing loads. The other is one in which the sides of the car beneath the windows form plate girders and carry a larger part of the load, the center sills being comparatively light. The Pennsylvania Railroad had in operation at that time a sample of both types of cars, the former being the one built at its own shops and the latter the Long Island car mentioned above.

Careful calculations were made by the committee which indicated that when the loads due to pulling and buffing are less than 100,000 lbs. the weight and cost of the car frame of either type will be practically the same. When, however, these strains exceed that figure the framing for the type where the sides carry the load increases considerably in weight, while for the center sill type the loads, due to pulling and buffing, may reach a value of 400,000 lbs. without any material increase in weight. In view of the primary requirements mentioned above these calculations led the committee to recommend the center sill type for cars used in through train service and a modification of that design for the suburban type, the modification being necessary to allow sufficient room for motors between the underframe and track.

DESIGN ADOPTED.

The design of framing finally adopted is one in which the weight of the car body is carried by the center sills at four points, two of which are near the ends of the sills and two between the trucks, the latter being located at points approximately the same distance from the center plates as the end loads. Reference to Fig. 1 will show the effect on the center sills of this method of carrying the loads, the shaded portions representing the live load and such part of the car as is supported directly on the center sills and the four arrow points the loads transferred to the sills by the end sills and cross bearers. The sill is supported by the trucks at the two points as shown. An inspection of the exaggerated deflection line will illustrate that the four points of support will be deflected practically the same amount and that therefore they will always be in line one with the other and no stress is placed upon the superstructure of the car by the deflection of the center sill. With this form of construction the sides of the car can be made comparatively light, as they have to carry but little transverse load and are supported at four points, and they can be designed principally to resist collapse in case of a corner blow or overturning. The fact that the side doors required by mail, express or baggage

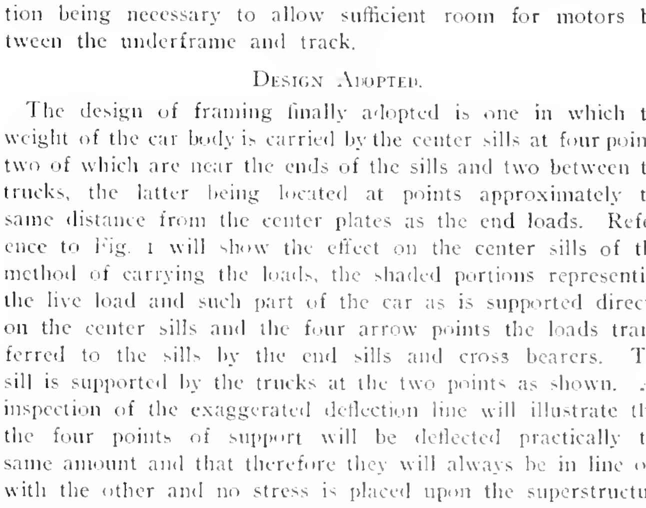
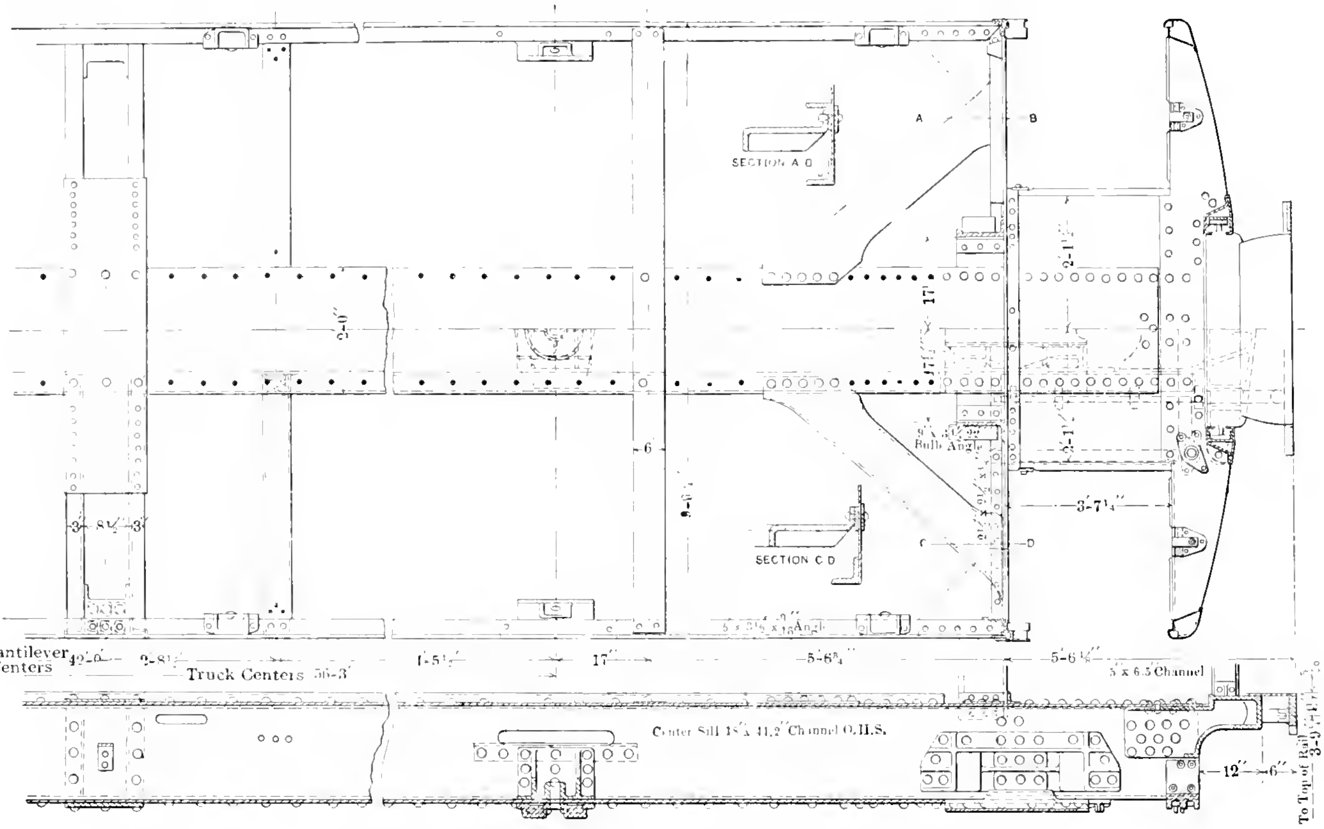


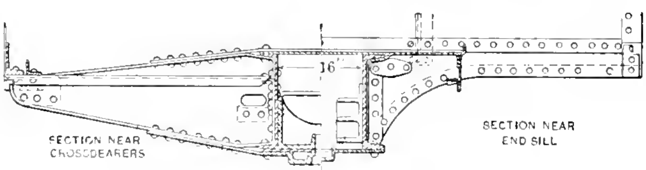
FIG. 1.

cars can be located where most convenient without requiring any material strengthening in the sides is also an important advantage.

In designing a center sill to fulfil these conditions it will be seen that it is possible to obtain practically equal fiber stresses



PLAN AND SECTIONS OF UNDERFRAME—STEEL PASSENGER COACH.



at the center of the sill and over the center plates, thereby giving a sill of uniform section throughout. At the same time a sill of sufficient depth to carry the load in this way permits the draw bar to be placed between the sills so that its stresses are transmitted directly to them instead of through auxiliary draft sills secured below. This eliminates a very serious bending movement at the end of the sills.

Through Service Passenger Coach.

In its general interior arrangement and appearance this car is almost an exact copy of the standard wooden passenger coach. It seats 88 passengers, has two large saloons in diagonally opposite corners and is estimated to weigh 113,500 lbs.

The Underframe follows the principles mentioned above and comprises two 18-in., 42.2-lb., channels set 16 in. apart and having ½ x 24-in. cover plates, top and bottom. These sills extend continuously from platform sill to platform sill. The weight of the superstructure is transferred to them by the body end sills, which are about 7 ft. from the truck center bearing, and by the cross bearers about 7 ft. 3½ in. inside of the center bearing. The distance between the cross bearers is 42 ft. The end sills are of the cantilever type, riveted to the center sills and built up of a web plate which is an extension of the end sheathing, and angles, top and bottom. The load is transferred to them partially by the corner posts and largely by the door posts. The cross bearers, which carry practically all of their load at the outer end, are also of cantilever form, being built up of two dished plates riveted to the center sills, set 8½ in. apart and having heavy top and bottom cover plates passing continuously above and below the center sill and riveted to the outstanding flanges of the web plates. These cover plates, however, extend only to a point about half way between the center and side sills. A malleable iron casting is fitted between the web plates at their outer end where the connection to the side sill is made. The side sills are of 5 x 3½ x 9/16-in. angles and are supported only at the end sills and cross bearers on top of which they rest. A series of nine struts composed of 5-in. channels are spaced between the side sills and center sills, being riveted to each and act as transverse stiffeners. The use of bolsters is not necessary in this design and the center plates are riveted directly to the bottom of the center sills, which are reinforced at this point by a steel casting secured inside. The side bearings are fastened directly to the side sills in line with the center plate. The connection between the side and end sills is stiffened by a gusset plate, as is shown, and two diagonal pressed steel shapes are fitted between the center sills and the outer end of the end sills, these being designed to resist the effect of a blow on the corner of the car and also to stiffen the structure of the underframe and keep it square. Projecting beyond the ends of the center sills are steel castings of special design, shown in the illustration, which act as a backing and support for the buffer plates.

The Main Side Posts are of pressed steel and are spaced 5 ft. 11 in. centers. They are of channel section and the edges are flanged out and riveted to the inside sheathing, thus forming a box section. They are securely riveted to the side sills at the lower end and the upper sections are tapered down and bent inward, forming lower deck carlines. At the upper end they are secured to the deck sill which is formed by a steel plate pressed into the shape shown in the illustration of the framing. It forms a continuous beam running the entire length of the superstructure.

Between the main posts are shorter intermediate posts, which extend only from the belt rail to the deck sill. They are of light channel section with edges flanged for riveting to the outside sheathing, forming a box section.

The Upper Deck Carlines are of sheet steel pressed to channel section with edges flanged out for riveting to the 3/32-in. steel roof sheet. The ends of the carlines are riveted to the combination deck sill and plate, to which the edge of the roof sheets are also riveted. Malleable iron posts of special design, located at the junction of each carline, act as stiffeners to the web of the sill and plate.

The Outside Body Sheathing is of ⅛-in. steel and the course below the belt rail is riveted to the outside sill and to

VIEW OF STEEL FRAMING.

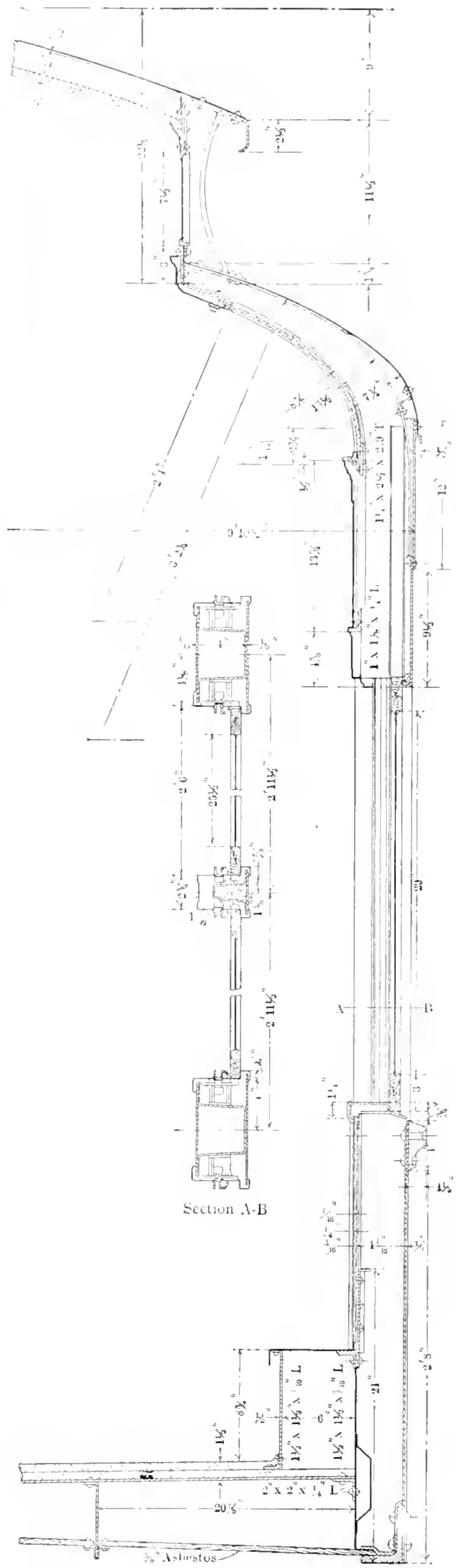
each post. The joints are butted and fitted with a cover plate. The steel shape forming the window water table laps over the side sheathing and under the belt rail. The outside sheathing above the windows is riveted vertically to the posts and its upper edge is secured to a channel shaped steel section forming the eaves for the lower deck and extending the entire length of the superstructure.

THE HEADLINING for the upper and lower decks is of composite board secured to the carlines and posts with metal strips. Below the belt rail the inside sheathing is of 1/16-in. steel, to the unexposed face of which 3/16-in. asbestos board is cemented. The bulkheads and remaining parts of the inside lining are of 1/16-in. sheet steel. Mouldings, closely resembling those used in wooden construction, are pressed from steel and their use adds greatly to the artistic appearance of the interior. By care in design it has been possible to almost wholly eliminate machine screws from the construction, and it is believed that economy in both construction and maintenance has been secured thereby.

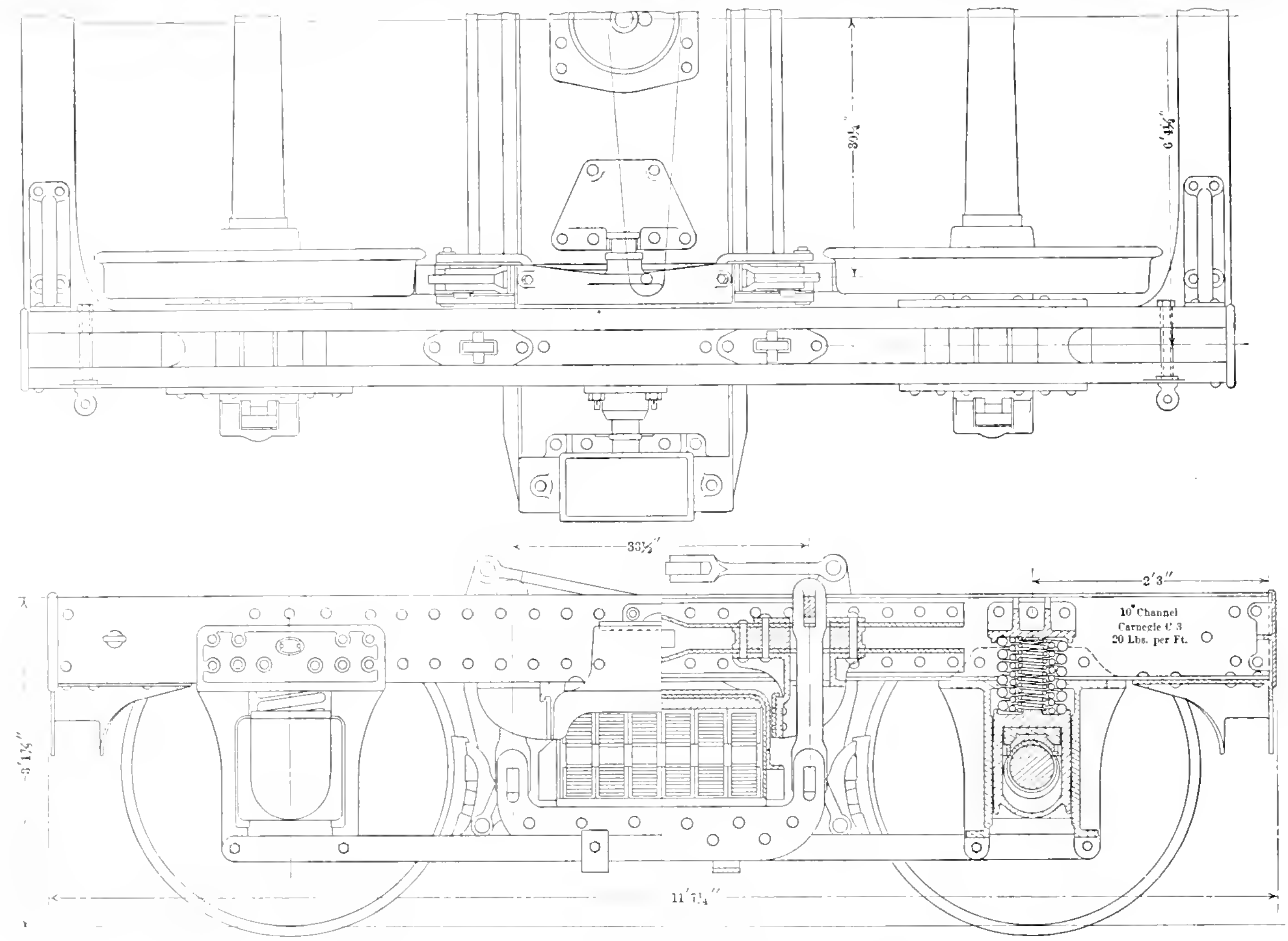
THE WINDOW SASHES are of wood and slide in pressed steel frames, which are supported and secured by malleable castings riveted to the posts. These castings are machined by jig, after being riveted in place, so that the frames will be true and parallel regardless of any slight irregularity in location of the posts. Window stops, which also form ways for the curtains, are of extruded bronze. The deck sash are of malleable iron.

THE FLOOR is formed by corrugated steel plates which are supported by the center sill and upon the longitudinal angles secured to the side posts. These corrugated plates are covered to a maximum depth of $1\frac{1}{2}$ in. with a plastic surface filling, composed largely of cement. A sub-floor of asbestos board $\frac{3}{8}$ in. thick supported by No. 20 galvanized sheet steel is secured to the center and outside sills. Along each side of the car just above the floor, rectangular ventilating ducts are provided, which enclose the heating pipes.

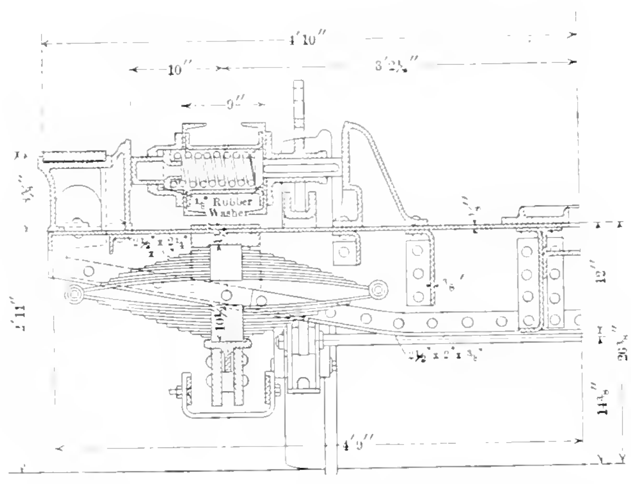
THE VESTIBULE.—Sufficient strength in the end of the car to prevent the superstructure from being swept from the underframe by the next car in event of a collision has been given careful attention. The center sill is the main support of the

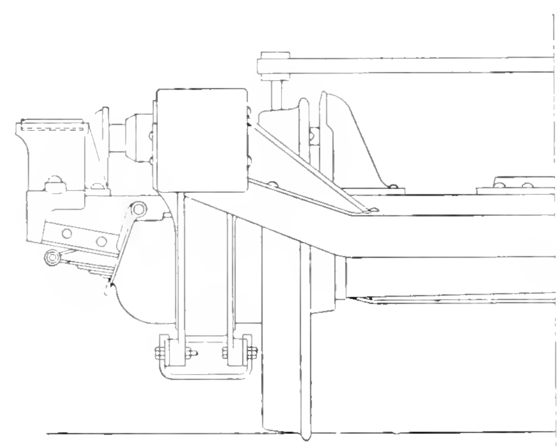


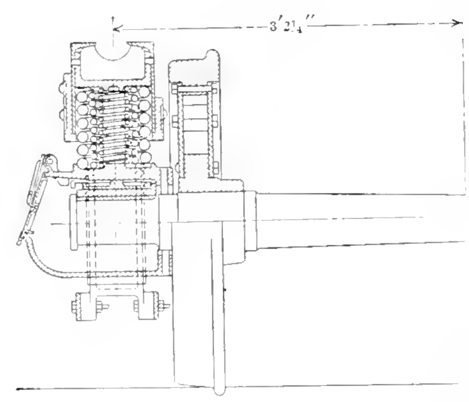
SECTIONAL ELEVATION THROUGH SIDE OF STEEL PASSENGER COACH—PENNSYLVANIA RAILROAD.



FOUR-WHEEL TRUCK—PENNSYLVANIA STEEL PASSENGER COACH.







entire vestibule and to it are securely fastened the 9-in. bulb angles forming the door posts. These, together with the 5-in. channels forming the vestibule posts, form the vertical members which are relied upon to prevent damage to the superstructure during collision. The vestibule floor plate, the end sills and sheathing, and the vertical bulb angles, are securely framed together to give an exceptionally strong foundation for the entire end construction.

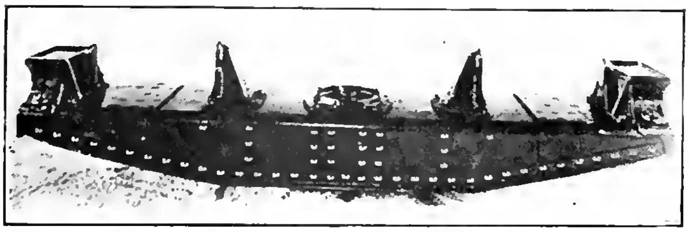
Vertical corner angles uniting with the sides and an angle across the top secured to the vestibule ceiling form the support for the end sheathing. Two diagonal braces running from the eaves down to the floor and securely riveted to the sheathing give additional stiffness to the ends.

The end of the vestibule is supported by two outside posts of pressed sheet steel together with two channel posts forming a doorway. The base is formed by a pressed steel platform end sill, and the top support is given by the vestibule ceiling plate.

Door jambs and lintels are of pressed steel closely imitating the forms used in wooden construction and are provided with cast diaphragms at intervals to prevent collapse and furnish support for attaching hinges, railings, etc.

The end construction of the roof is of formed steel plates reinforced by angles secured to the end carline and the vestibule ceiling.

HEATING AND VENTILATING.—The passenger coaches will be equipped with a ventilating system by which, with all windows and doors closed, each passenger will be supplied with 1,000 cubic feet of fresh air per hour, which is equivalent to a complete change of air in the car every four minutes. The air is taken in by two hoods situated on diagonally opposite corners of the car roof. From each hood a vertical duct leads down, within the side of the car, to the horizontal duct which runs the entire length of the car, between the floor and the sub-floor next to the side sill. Above the floor of the car, and running its entire length along the sides, are the rectangular ducts, mentioned above, which contain the steam heating pipes. After circulating about the heating pipes and becoming thoroughly warmed the air is delivered into the aisles of the car through tubular outlets beneath each seat. It is discharged from the car through ventilators in the roof, which are provided with

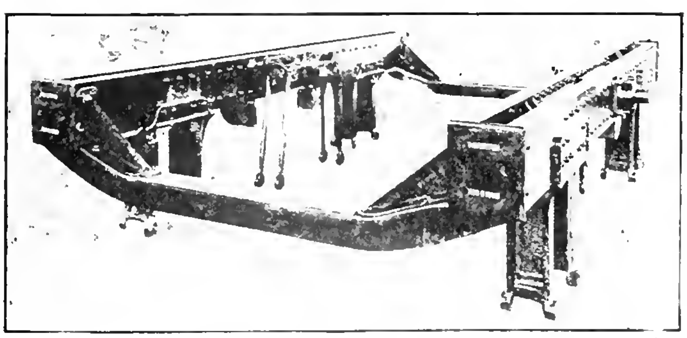


BOLSTER—FOUR-WHEEL STEEL TRUCK.

valves. The movement of the car forces the air into it under slight pressure and by limiting the discharge this pressure is maintained and the entrance of cold air through cracks about the doors and windows is prevented. This system works equally well in either winter or summer. The warming of so much fresh air, however, requires considerably more steam than would be needed by the usual methods of heating without much, if any, ventilation.

TRUCKS.—An entirely new form of truck is required for these cars owing to the fact that the very deep center sills lower the center bearing plate to a point where it just clears the axle of the 36-in. wheel, having a 5 x 9-in. journal. As will be seen from the table above, both the six-wheel and four-wheel type of truck are required on different cars. The four-wheel truck is the one used on the passenger coach and will be considered first.

This truck is of steel throughout and weighs but 12,500 lbs.



TRUCK FRAME—FOUR-WHEEL STELL TRUCK.

The ordinary wooden truck of the same capacity would weigh 16,000 lbs. The most noticeable feature of the general design is the elimination of the usual equalizers and the adaptation of the wheel pieces for this purpose. The wheel pieces consist of two 10-in. channels with the flanges turned inward and set 9 in. apart, outside measurement. The two channels are spaced and secured together at several points by filling pieces and supports for hangers and springs. The wheel pieces are connected by two cross bars, one at either end, each formed of steel pressed in channel shape. These are depressed in the center in order to clear the center sill. They are secured to the bottom of the wheel pieces and further stiffness is obtained by a malleable iron knee between the wheel piece and the cross bar.

The weight from the center plate is transferred to a bolster, built up of pressed steel shapes and angles in channel section. It has a depth of 12 in. at the center and is 26 in. in width. This bolster extends some distance beyond the wheel pieces and is supported by twelve elliptical springs, six at either end, which in turn are carried on a cast steel base hung by links from the wheel piece. The casting which forms the bearing and filling piece at the connection of the hangers to the wheel pieces is extended downward and forms a stop and guide for the bolster on either side. A spring centering device, the arrangement of which is clearly shown in one of the illustrations, has been incorporated.

The pedestals are secured to the wheel piece in the ordinary manner and are connected at the bottom by two tie rods, sufficient space being given the rods to permit the use of the jack on the bottom of the journal box. The weight is transferred from the wheel pieces to the journal boxes through nests of coiled springs resting on top of the boxes and extending up between the two channels, the lower flanges of which are cut out at this point, to a cast steel spring cap.

The side bearings are incorporated in the casting forming the outer stop of the spring centering device, which is connected on the extreme end of the bolster and comes directly below the side sill of the car.

In the brake rigging the principle of an independent set of duplex brakes for each side has been carried out and brake beams have been entirely dispensed with by directly suspending the brake-heads from hangers attached to the wheel piece.

The six-wheel truck, postal, baggage and suburban cars will be considered in our next issue.

WRITING FOR TECHNICAL JOURNALS.

The easiest way to find how little you know about a particular subject or thing is to endeavor to write about it. Unqualifiedly, I believe this to be true. How many of us have started to describe some little thing only to discover that at some point we must do a little investigating before we could go ahead! In description of principle or fact we must get the successive steps in their proper sequence and true relation if our ideas are to be conveyed logically to the reader or before they will "sound right" to us when we read them. So I believe that whether our subject be a chicken-coop or a 10,000-horse-power plant we know more about it after we have described it than we did before; our ideas are clearer, more logically formed. This is no new principle; it is applied in every school and college to-day and why is it not as applicable here?

But the greatest benefit derived is that of the interest stimulated by writing. If we get into the habit of describing things about the shop our interest grows, our knowledge broadens. If our story about a special chuck is published we inadvertently feel a pride in it, and want to see what the other fellows are saying and so we read more and our interest broadens.

Someone's description of a milling fixture may have helped you out of a hole; so you want to give other readers anything you have "up your sleeve" in return. And so you gradually obtain the power of *seeing* things, not just *looking* at them.

Every foreman, no matter how large or small his shop, has done something that is worth telling about. How much better it would be for him if he would not stop at developing the idea but would write it up for publication and in so doing stamp its principles upon his mind and at the same time develop his receptive powers and become on the alert for someone else's ideas that he can apply to his own work.—*"Egypt" in the American Machinist.*

THE EFFICIENCY OF THE WORKER AND HIS RATE OF PAY.

By Clive Hastings.

All workers should be paid in proportion to their efficiency. The efficiency of a worker depends upon the amount of work done. A measure of efficiency is the ratio of the amount of work actually accomplished to the amount of work performed by a standard worker. Day work, piece work, and the various premium systems all attempt to pay the man who does the most work the most money, or, in other words, to pay the efficient higher than the inefficient. This is done under the day rate by rating those highest whom the foreman or manager considers worth the most. Under the piece work or premium systems this is done automatically, but difficulties arise in the matter of changing conditions which necessitate continued changes and adjustment of schedules.

Some system is needed by which the rate of pay will be automatically adjusted to meet changing conditions. This can be done by paying the individual worker on a sliding scale depending upon the ratio of his efficiency to that of other workers of the same class working on the same class of work under the same conditions.

To be fair piece rates should be continually adjusted for every change in conditions. Hard castings in a machine shop warrant an increase in the rate per piece and improved methods or tools warrant a decrease in the rate per piece.

The bonus or premium system insures the worker a fixed amount of wages which should be the same as that of the day worker of his class, with an increase in the form of bonus for efficiency. The straight wage remains constant, but the bonus varies with the worker's efficiency. Efficiency under the bonus system is determined by the ratio of the time to perform an operation, or set of operations, to a standard or schedule time assigned in which to perform it. If standard time is ten hours on a certain operation and the workman does this in ten hours his efficiency is 100 per cent. If he does the work in eight hours his efficiency is ten divided by eight, or 125 per cent. If he does the work in fifteen hours his efficiency is ten divided by fifteen, or 66⅔ per cent.

As in piece work a constant adjustment of rates is needed for every change in conditions, so in bonus work there should be a change of schedule for every change in conditions. The demand for adjustment is not so urgently called for by the bonus worker as the major part of his pay comes to him as a straight day wage and he takes the changing conditions of hard or soft castings, good or poor crane service, etc., as a matter of luck, but is continually striving to increase his output or efficiency for the sake of the resulting increase in pay. Both the bonus system and the piece rate system require the establishing of schedules and rates. The method of establishing piece rates may be by careful time studies or by judgment on the part of those making the rate.

The greatest difficulty in establishing a piece rate is that very few (the worker included) realize the marvelous rapidity with which work can be done when the incentive is great enough. When a rate is set on a certain operation it should be high enough to insure the worker a fair rate of pay. It will be found, however, that on account of the incentive to get out more work he is getting out so much more or becoming so much more efficient that an adjustment of the rate has to be made and this kind of adjustment of piece-work rates is the thing that has made the workmen so opposed to piece work. They believe that as soon as one begins to make a high rate of wage the price per piece will be cut. This produces a sentiment of doing just enough to earn the ordinary rate of pay of men of their class working in day-rate shops and no more. When this happens the object of piece work has failed as the men are not striving to increase their output beyond a certain point. In other words, if our piece-work price is too high we do not find it out on account of the worker only doing a limited amount, then idling the rest of the working day.

If a piece-work rate is set too low an injustice is done the worker, for in this case he is unable to make the wages of other men of his station in life and soon becomes dissatisfied and quits. If the piece-work price is set where it should be to begin with, it looks so low to the worker that he feels he cannot make living wages. As a matter of fact he cannot until after several months of practice, during which period he has not been earning as much as he should and is very likely to become discouraged and quit before he has become efficient enough to earn his just rate of pay.

Summing up the above in regard to piece work:

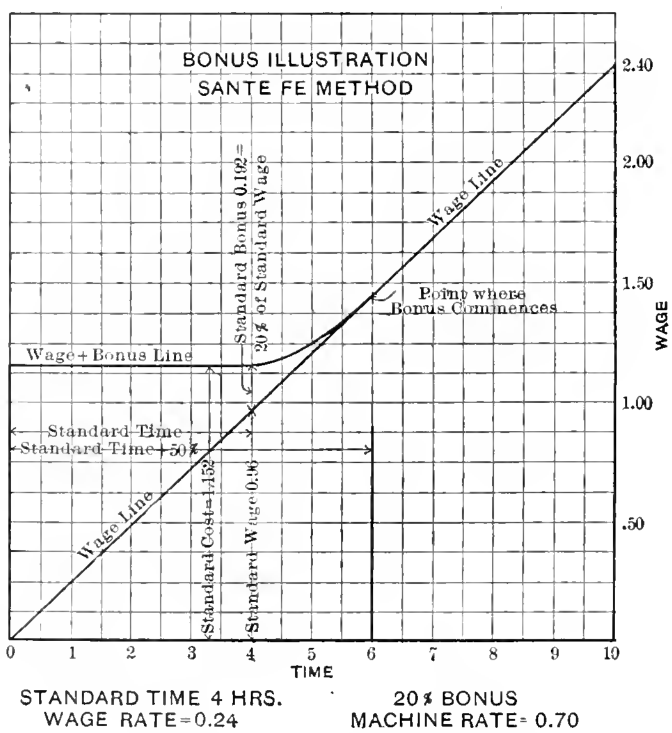
First. If rates are too high it is not discovered as the worker so sets his pace as not to make an excessive wage for fear the rate will be cut if he does.

Second. If rates are too low the worker becomes discouraged and quits.

Third. If the rates are such that the worker will make a just rate of pay, after he has reached his maximum efficiency by practice the rates will be so low that during the period of becoming efficient he will not receive a just wage and will become dissatisfied.

The bonus system overcomes these difficulties, for during the period of transition from day work to that of maximum efficiency he has received his straight day rate plus a bonus figured on a sliding scale as his efficiency increases from 66⅔ per cent. to 100 per cent. The schedule can be made as low as it should be, yet the worker is not disheartened, and when he reaches maximum efficiency his total wage is not exorbitantly high.

It is customary to make the bonus schedule such that the worker making it, or reaching 100 per cent. efficiency, is entitled to 20 per cent. increase in his day-rate wages and to make the day rate the same as other workers of his class are making under a day-rate system. If the worker takes one-half more time than the schedule or works at 66⅔ per cent. efficiency he receives no bonus. The bonus increases on a sliding scale from 66⅔ per cent. to 100 per cent. efficiency, at which point the bonus is 20 per cent. of the wages. For all increases in efficiency above 100 per cent. the worker is paid in bonus 20 per cent. of his wages for standard time plus the number of hours saved times his rate of pay per hour. Thus the total pay for any operation done in over 100 per cent. efficiency is the same as if his efficiency was 100 per cent., which means that the wage cost at 100 per cent. efficiency is a standard price for the operation.



GRAPHICAL ILLUSTRATION OF BONUS SYSTEM.

Under the bonus system, then, we can establish a just price as standard and by means of the sliding bonus scale induce the worker to achieve maximum efficiency without feeling that at any time during the transition he has been forced to take a lower wage than he deserves, and when he has reached the point of maximum efficiency it is not necessary to cut the schedule as has proved the case so many times with piece work.

Piece work and bonus systems are methods that automatically pay the efficient more than the inefficient, and the bonus system, with the guaranteed day wage, leads to fewer difficulties in the way of discontented workmen during the period of transition from day work to that of maximum efficiency. Changes in the conditions do not affect the total wage to as great an extent and the workers therefore are less discontented when conditions work to their disadvantage. The extra money in the form of bonus is a continual incentive to make them strive to work at their maximum efficiency. Granting that we have bonus schedules which are fair and just for conditions as they exist to-day, these conditions will not be the same to-morrow, and in strict justice the schedules should be changed with each change in conditions. This would be such an interminable task that no piece-work or bonus man would ever think of attempting it. The friction and disputes that would constantly arise would upset all shop discipline and organization. For this reason schedules are made as near right as possible and allowed to remain constant under the theory that month in and month out the conditions will vary as much one way as the other and thus be balanced.

The attempt of the employer who works his workmen under a straight day-rate system is always to rate the efficient higher than the inefficient. This can be done and is accomplished very satisfactorily in a small organization where the employer can know all his men personally and is allowed a free hand to rate them according to his judgment. In large organizations it is impossible to know each man personally, and as soon as the personal element is lost it becomes necessary to pay whole groups or classes of workers a uniform rate rather than a varying rate based on efficiency determined by personal knowledge of the employer, as was possible in the small organization. Some form of premium or piece-work system is then resorted to as a method of determining efficiency and thus paying the efficient more than the inefficient. It has been shown that these systems do this automatically. It has also been shown that unless schedules are continually being adjusted no account can be taken of varying grades of materials or tools, etc. The next step, then, is a system which will take care of these variations automatically.

The efficiency of men working side by side in day-rate shops has been found in cases to vary from 40 per cent. to 120 per cent., yet the rate of each man was the same. Efficiency of 40 per cent. means that 100 hours are actually taken to perform work scheduled as requiring 40 hours. Efficiency of 120 per cent. means that 100 hours are actually taken to perform work scheduled as requiring 120 hours. The worker working at 120 per cent. efficiency does three times as much work per hour as the worker of 40 per cent. efficiency.

The employer is evidently satisfied, though probably through ignorance, with the man of 40 per cent. efficiency, for if the employer is not satisfied the man would be discharged or his rating cut in three. Granting he is satisfied with the worker of 40 per cent. efficiency the employer would be no loser, in fact he would be a gainer on account of increased output, if he paid the worker of 120 per cent. efficiency a bonus of 200 per cent. of his wages in addition to his straight day wage. This is an extreme case though not an uncommon one.

Every employer should be willing to pay the man in his shop, whose efficiency is that of the average efficiency of the whole shop, a wage equal to the highest day wage that man can obtain in a day-rate shop in the same section of the country. If we then assign standard or schedule times for every job given a worker it is a simple matter at the end of each day, week, month or period to sum up the total of the schedule hours of all jobs he has performed and then by dividing this total by the actual hours worked determine his efficiency.

In the same way the time efficiency of the whole shop can be determined by dividing the sum of all the schedule hours of work performed by the sum of the actual hours worked by each man as shown by time clock. Having determined the efficiency of the shop as a whole we can compare the efficiency of each man with this and base his rate of pay on the ratio his individual efficiency bears to the whole shop efficiency. The man whose efficiency is the same as that of the shop will receive a wage equal to the highest day wage which workers of his class receive in the same locality. The man whose efficiency is above that of the shop will receive a total wage which bears the same ratio to the wage of the man whose efficiency is the same as that of the shop as his own efficiency bears to the whole shop efficiency. Also the man whose efficiency is less than that of the shop will receive a total wage which bears the same ratio, to the wage of the man whose efficiency is the same as that of the shop, as his own efficiency bears to the whole shop efficiency.

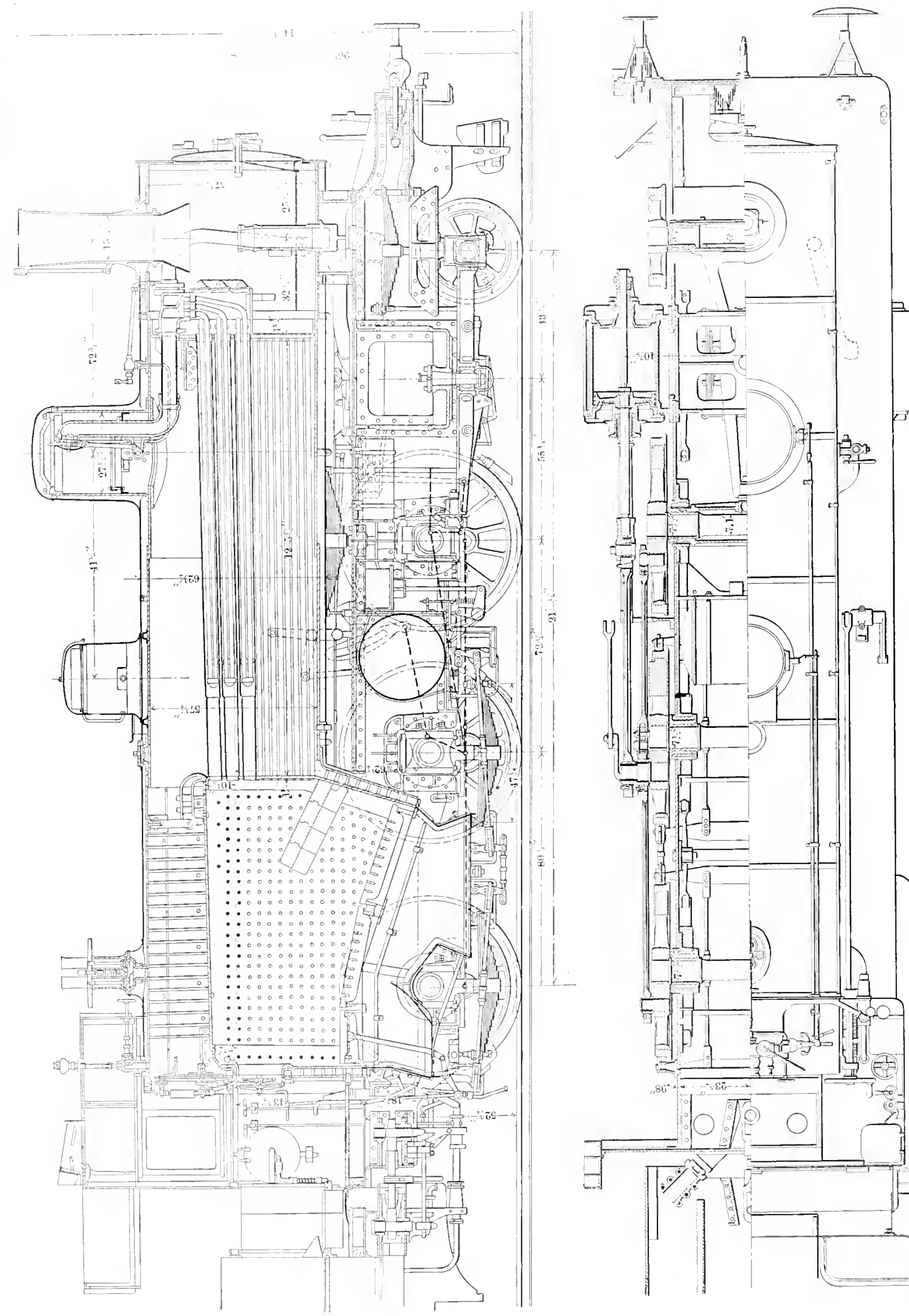
It will be better to divide the workers into groups much the same as is done in a day-rate shop, all the workers on a certain class of machines in one group, all those doing bench work in another, and so forth down to as minute grouping as desired. After dividing the shop into groups the wages of each individual worker should be based on the ratio of his efficiency to that of the efficiency of his group as a whole.

The advantage of basing the worker's wages on the ratio of his efficiency to that of the efficiency of his group is that all variations in conditions are thus automatically adjusted, and after schedules have once been established they may be left indefinitely without a change.

Assume as an example the case of a worker who is one of a group of six all doing small lathe work. Our schedules have all been made as fair and just as possible for existing conditions. Next month the castings coming from the foundry are discovered to be a much harder grade of casting than those of to-day. Under a straight bonus or piece-work system the only fair thing to do is to adjust the rates or schedules, allowing more time on account of this hard run of metal. Under the proposed system of paying men based on group efficiencies this is not necessary, for when the hard castings are brought in and the schedule left unchanged the efficiency of the whole group will fall and that of the individual will fall in proportion. We will continue to pay the worker whose efficiency is equal to that of the group the highest wages he could get under a day-rate system, and those whose efficiency is above or below the group efficiency will be paid in proportion. Assume again the same group and that all other things being equal we suddenly introduce a new tool steel allowing the cutting speed to be doubled. Under bonus or piece work it is immediately necessary to cut the schedules in two, with its accompanying discontent and grumbling from the worker. Not so with the proposed plan, for when the new steel is introduced the efficiency of the group immediately doubles and that of each individual worker increases proportionately. We will continue to pay the worker whose efficiency is equal to that of the group the highest wages he could get under a day-rate system, and those whose efficiency is above or below the group efficiency will be paid in proportion.

SUMMARY.

Summing up:—Every system of paying labor is an attempt to pay the efficient more than the inefficient. The straight day rate in which the attempt is always made to rate the workers by their efficiency gave satisfaction with the smaller organizations of the past in which the personal relation between employer and employees were such that by personal knowledge the employer determined the rating of each man. With the increase in the size of organizations the personal relations between employer and employee have become such that the employer is unable to know his employees personally and thus be able to rate them according to his personal knowledge of their individual ability or efficiency. As a result he has turned to piece-work and premium systems as automatic means of determining efficiency and adjusting wages accordingly. The piece-work and premium systems both do this, but any arbitrary setting of rates or schedules cannot stand without continual adjustment to meet varying conditions that are never twice exactly alike.



SIMPLE MOGUL PASSENGER LOCOMOTIVE WITH IMPROVED SCHMIDT SUPERHEATER—SWISS GOVERNMENT RAILROAD.

The premium system with guaranteed day wage needs less adjustment than a straight piece-work system. Even under the premium system employee and employer are continually insisting upon adjustment of schedules to meet changing conditions. These adjustments are continual causes of strife and ill feeling.

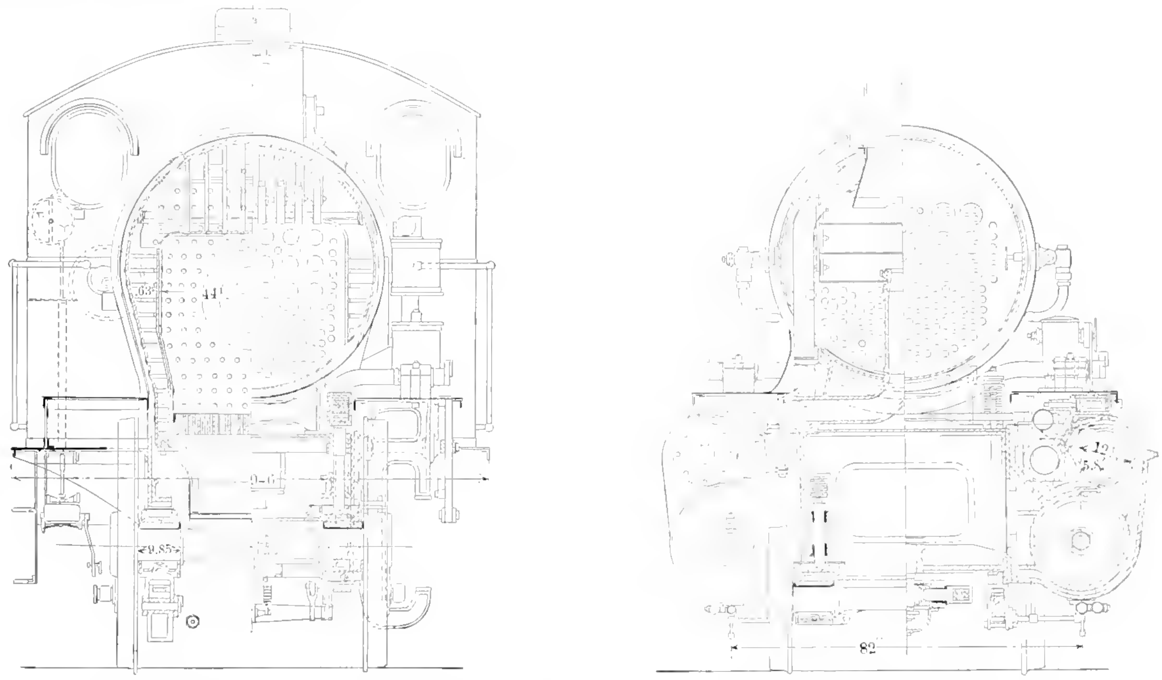
The next step toward a just wage is a system of wage rating which shall automatically adjust itself to these changing conditions. This is accomplished:

(1) By scheduling every operation for conditions as they exist. These schedules to always remain the same.

(2) By dividing the workers into groups, all in the same group being employed on the same class of work.

(3) By determining the efficiency of individual workers and groups by dividing the total schedule hours performed by the total hours actually taken.

(4) By paying each worker whose efficiency is equal to that of his group the maximum pay he can get under the day rate system, and varying the wages of those whose efficiency is above or below that of their group in the same ratio that their efficiency bears to that of their group.



SECTIONS OF MOGUL TYPE PASSENGER LOCOMOTIVE WITH SUPERHEATER—SWISS GOVERNMENT RAILROAD.

SIMPLE LOCOMOTIVE FITTED WITH IMPROVED SMOKE TUBE SUPERHEATER.

SWISS GOVERNMENT RAILROAD.

BY WILHELM SCHMIDT.

Generally speaking, mogul locomotives are still in considerable favor in Europe, where the demand for larger and heavier engines has not been of that urgent and persistent character which has been so marked a feature in the case of America. This is mainly due to the fact that highly superheated steam has for some years been extensively employed on the European Continent, as a result of which it has been possible to adequately increase the power of new locomotives without augmenting the total weight to an undesirable degree. The engine shown in the accompanying engraving is especially interesting for the reason that it is provided with the latest improved smoke-tube type of superheaters, a type which is as steadily increasing in popularity in Switzerland as it is elsewhere. Apart from the superheating apparatus and certain other parts which work under steam, the design of the engine as a whole is a typical one for this class of locomotive on the Continent of Europe.

THE BOILER, which embodies features closely allied to American practice, is of the narrow firebox type. The inside firebox is of copper, the sides and crown being in one sheet, ⅝ in. thick. The crown sheet is flat, with a slope towards the back of about 2¼ in., and is supported by vertical stay bolts. There are also horizontal stays extending across from the sides of the boiler shell, and placed immediately above the crown-sheet. The mud-ring is only 2 9/16 in. wide. The back and front flue-sheets are each about 1⅜ in. in thickness, the former being of copper and the latter of steel. The boiler has a diameter of 55¾ in. at the front ring, and contains 150 tubes 12 ft. 7¾ in. long. Of these tubes, 132 are 1¾ in. in diameter, while the remaining 18 have a diameter of 5⅛ in.

As will be seen from the drawing, the latter are disposed in the upper part of the barrel, and it is in this group of larger tubes that the new smoke-tube superheater is arranged. The earlier forms of this apparatus are familiar to the readers of the AMERICAN ENGINEER, owing to its application to engines on the Canadian Pacific Railroad. The present modification of the superheater possesses several mechanical and other advantages over the original design. Its principle and construction are clearly shown in the detailed drawing. There are two important features which constitute the chief differences between the new and the old smoke-tube apparatus. One feature is that the superheater pipes are now formed in double loops instead of in single loops, while the other is that each set of superheater pipes is independently bolted, and can be got at without disconnecting or in any way disturbing the adjacent sets.

Each of the 18 large smoke-tubes, A, contains a superheater element, B, consisting of four solid-drawn steel pipes, of 1¼ in. diameter, which are connected at their firebox ends by two steel return bends, thus forming a double loop, as shown in detail. The two ends of each set of superheater pipes are bent upwards in the smoke-box, and are there spread apart, in order to allow for the full expansion of the pipes under different temperatures. At the same time this arrangement permits of the smoke-tubes being just as easily inspected and cleaned from the front end of the boiler as from the firebox end. This feature is of very great importance in the case of boilers with long tubes, and more especially so if poor coal is used, as then the cleaning of the smoke-tubes from the firebox end alone cannot always be efficiently performed. Again, as there are no header castings hanging down in the smoke-box, no difficulty whatever arises with regard to the resetting or removal of the large tubes, either of which operations can be readily carried out, without disconnecting the whole arrangement.

There are as many superheater elements as there are smoke-tubes, hence there are 18 in the engine under notice. The two smoke-box ends of each set of double-looped superheater pipes, B, are expanded into a flange, C, which is independently secured to the bottom face of the cast-iron steam collector, D, in the smoke-box, by means of a single 1 in. bolt, E. The heads of these bolts are movable in slots in the underside of the collector casting. In the most exceptional case, it would not be necessary to loosen more than three of the holding bolts in order to draw out any particular set of superheater pipes. This feature thus renders the new apparatus thoroughly practicable and accessible. An all-round even joint is obtained by passing the bolt through the centre of the flange, and supplementing it with a couple of copper-asbestos rings. Only 18 of these 1 in. bolts are needed for the purpose of fastening the whole superheating arrangement to the collector casting, and there are neither coupling-nuts nor screw connections in the smoke-box which would cause any trouble through leakage.

The collector casting is divided by partitions into compartments for saturated and superheated steam alternately. These compartments communicate with the corresponding ends of the superheater pipes in the smoke-tubes. On the throttle-valve being opened, the saturated or moist steam flows from the dry-pipe into the several compartments for saturated steam, then passes through the double-looped superheater pipes (as indicated by arrows), and returns highly superheated to the other compartments in the collector, from which it finally passes to the cylinders in the ordinary way.

The passage of the combustion gases, and therefore the degree of superheat in the smoke-tubes, can be regulated by means of dampers fitted to the collector casting in the smoke-box. For the purpose of preventing overheating of the superheater pipes, these dampers are kept closed while the engine is standing or drifting, as the case may be.

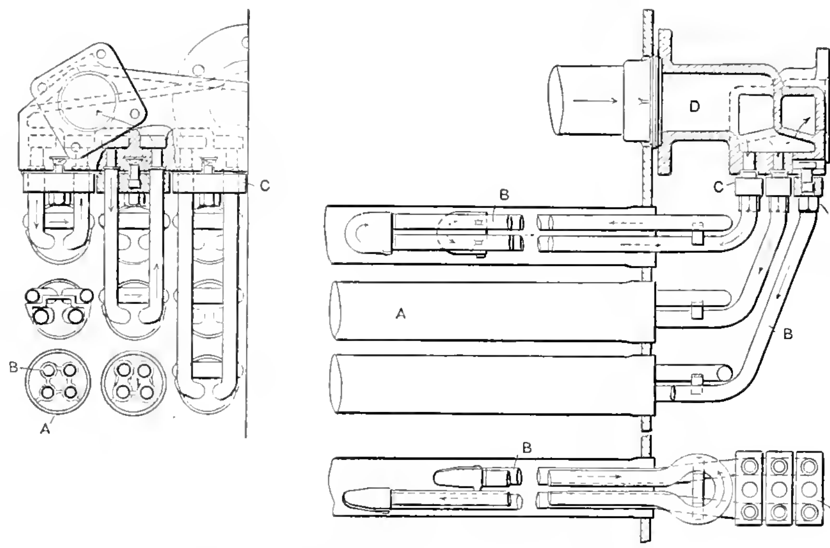
The ratio of the heating surface of the superheater (307.9 sq. ft.) to the total heating surface of the boiler (1,512.4 sq. ft.) is ample to insure an average temperature of the steam in the steam-chest of from 580° to 600° Fahr. Such a high degree of superheat is absolutely necessary in the case of simple locomotives, in order to avoid *all* condensation in the cylinders, by which result alone can the entire benefit of superheating as regards great economy and efficiency, be obtained. Manifestly, the complete prevention of condensation is equivalent to a larger boiler capacity, so that, with a view to fully utilizing this increased steaming capacity, cylinders of a comparatively large diameter are necessary. For an engine of the size of this mogul locomotive, 21¼ in. cylinders would undoubtedly be deemed too large in America. The engine would be regarded as being over-cylindered, and assuredly it would be so, if saturated steam was employed. But the possibility of using large cylinders in an economical manner, is one of the salient features of this system of superheating, while it is the principal source of the greatly increased efficiency of the numerous locomotives which have been fitted with it. As compared with ordinary-size cylinders, highly superheated steam allows of earlier and more economical cut-offs, both at starting and while running; and, what is even more important, it also permits of the use of relatively low boiler pressures.

In the case of locomotives working with saturated steam, the size of the cylinder is quite as much restricted by the losses due to condensation as by the loading-gauge limits. It is necessary to employ comparatively small cylinders, which, in turn, means the use of late and uneconomical cut-offs when the engine is starting or being forced. On the other hand, with locomotives using highly superheated steam, the total absence of condensation enables the diameters of the cylinders to be so increased that economical cut-offs are possible, in addition to which advantage, an increase in the tractive power is obtained simultaneously. The comparatively early cut-offs with which the engines can be started, reduces the tendency of the drivers to slip, in consequence of which superheated steam locomotives are given a greater lap on the steam side of the valves, so that they start away under full steam with short cut-offs, and are far less liable to slip than are saturated steam locomotives.

As in the case of the engine illustrated, the large cylinders fitted with piston-valves necessitate the use of by-pass valves. The drawing shows a very simple design of such a valve, arranged on the top of the steam-chest and actuated by hand.

Pistons provided with three small square-section spring rings of cast-iron are used. The rings are grooved, and there are a number of small holes in the periphery of the first and third rings, in order to avoid compression of the outer ring at the end of the stroke, and to equalize the pressure of the steam which leaks behind the rings. When highly superheated steam is employed, it is particularly desirable to secure steam-tightness with a minimum of friction. For this reason, a long tail-rod to the piston is used, and the weight of the piston is counter-balanced by this rod on the one side, and by the crosshead on the other. In this way, the friction of the piston-rod proper when moving in the packing is reduced to a minimum.

The double-ported piston-valves, with solid rings, are arranged for inside admission, and are operated by the Walschaert gear. As on the outside of the valves there is only the relatively low exhaust pressure, no stuffing-boxes for the valve-rods are required or used. On account of the double admission, and owing to there being no bridges in the steam ports—the rings being solid—the diameter of the piston-valves can be kept very small. An important point in favor of highly superheated steam is that its great tenuity makes the use of piston-valves of a comparatively small diameter possible, even in the case of locomotives designed for high-speed passenger service. To prevent jamming of the solid rings, the steam-chest is steam-jacketed.*



SCHMIDT IMPROVED SMOKE TUBE SUPERHEATER.

Forced lubrication, with mineral oil having a high flash-point, is used for the cylinders and valves, in order to insure efficient lubrication.

The Frames are of the usual plate type employed abroad, and are 1 in. thick. The underhung springs of the back and intermediate drivers, together with the overhung springs of the front drivers and truck wheels, are equalized, so that the weight is compensated between two distinct groups of wheels. The truck, however, is not provided with a cross equalizer. It will be noticed that all the spring-hangers are adjustable in length.

The Pony Truck is of the Krauss-Helmholtz type, and its construction is clearly shown in the drawing. A noticeable feature is that the axle is connected with the leading drivers by a radius-bar whose fulcrum lies between the truck and driving

* These piston valves were designed by Mr. Schmidt, who has also devised several other forms of such valves fitted with split rings, which have proved to be very successful and have been extensively adopted by many European railways.—Ed.

axle. The latter has a certain amount of lateral play, and acts, in its combination with the pony truck, like a four-wheeled engine truck. Hence, locomotives of this type are well-suited to either fast passenger or ordinary freight service.

The principal dimensions of this engine, which was constructed at the works of the Swiss Locomotive and Machine Company at Winterthur, Switzerland, are given in the following table. Twenty engines of the same type are either already at work on the Swiss Government Railroad, or are in course of being built for that system:

Diameter of cylinders	21.26 in.
Piston stroke	23.62 in.
Diameter of driving wheels	59.8 in.
Heating surface of tubes	1,072.1 sq. ft.
Heating surface of superheater	307.9 sq. ft.
Heating surface of firebox	132.4 sq. ft.
Total heating surface	1,512.4 sq. ft.
Grate area	24.8 sq. ft.
Boiler pressure, per sq. in	170.7 lbs.
Diameter of boiler (front end)	55¾ in.
Number of ordinary tubes	132
Diameter of ordinary tubes	1¾ in.
Number of superheater smoke-tubes	18
Diameter of superheater smoke-tubes	5⅛ in.
Length of tubes	12 ft. 7¾ in.
Weight of engine in working order	123,630 lbs.

A TIME AND COST COMPUTER.

An interesting and valuable application of the logarithmic principle of the slide rule, for the simple solution of problems in connection with boring and turning mill and lathe work, has recently been made by Mr. William Cox, a mechanical engineer of New York City, in the design of a "time and cost computer" for The Bullard Machine Tool Company, of Bridgeport, Conn. This instrument, which is illustrated herewith, is practically a circular slide rule in which the various scales—six in number—have been given special values corresponding to the elements which enter into the calculations.

The formula which it solves:

$$T = .2618 \frac{D \times L \times F}{S}$$

is derived as follows:

$$T = \frac{L \times F}{R}, \text{ in which } R = \frac{S \times 12}{\pi D}, \text{ which resolves into}$$

$$T = \frac{L \times F}{\dfrac{S \times 12}{\pi D}} = \frac{\pi}{12}\left(\frac{D \times L \times F}{S}\right) = .2618 \frac{D \times L \times F}{S} \text{ in which}$$

T = Time required in minutes.
D = Diameter of piece in inches.
L = Length of cut in inches.
F = Rate of feed per revolution in parts of 1 in.
R = Revolutions of piece per minute.
S = Cutting speed in feet per minute.

The usefulness and time-saving qualities of the instrument, as compared with the usual pad and pencil method, are well illustrated in the following example (a cast-iron cylinder being assumed: Cutting speed 35 ft. per minute (A), feed per revolution ⅛ in. (B), diameter of piece 30 in. (C), length of cut 20 in. (D), time required 36 minutes (E), the accompanying illustration showing the scales set in the required positions for the solution of the problem. Another scale, not shown, determines the cost per operation at an hourly rate of from 1 to 60 cents. The determination of the proper feeds and speeds to be used for the completion of a certain operation in a given time is another valuable feature.

The Bullard Machine Tool Company has arranged for a supply of these, at a considerable expense, and we are advised that they will be glad to furnish them to motive power officials or foremen, who may have need for them, if an application is made, the applicant to state his position and the company he is with.

EQUALIZERS ON PASSENGER TRUCKS.

TO THE EDITOR:

The equalizer, so called, in a passenger truck is an equalizer in name only, for it does not equalize. It is merely a rigid bracket for supporting the helical springs, which might as well be supported on the journal-boxes. What equalizing there may be is due to the action of the wheel-pieces as equalizers.

The truck shown in Fig. 2, page 180, is just what is advocated by those who would omit the equalizer. There we have springs over the boxes, supporting the truck frame. The piece having the shape of an equalizer we can call a "wheel-piece truss rod," or a "spring seat hanger," and we shall have in principle just such a truck as that of the New York Central car, page 81 (March issue). The omission of equalizers would reduce the weight of each truck by about 600 lbs.

It is a mistake to consider that the best American roadbeds are not as good as any to be found in Europe, and that the riding qualities of European trucks are thereby explained.

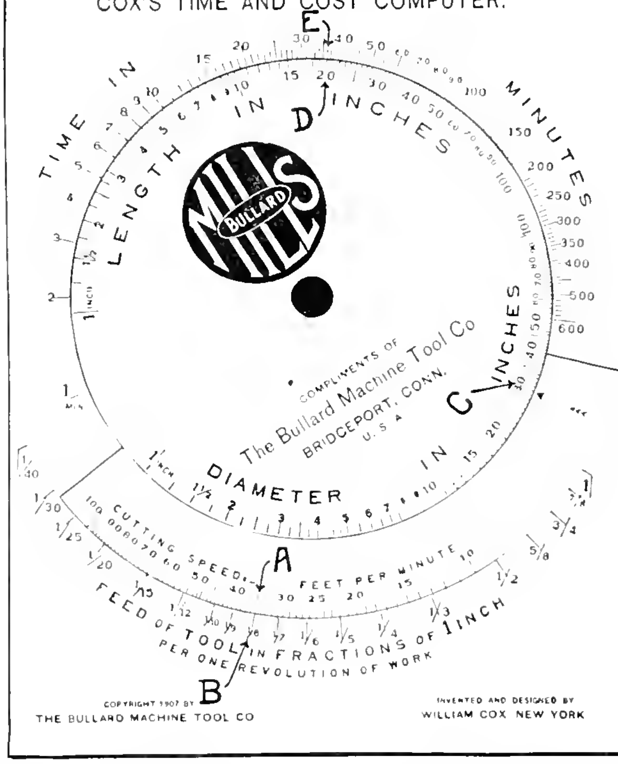
T. Y.

TO THE EDITOR:

Below are noted some thoughts that occurred to the writer on reading the communication on "Equalizers on Passenger Trucks" in your May issue.

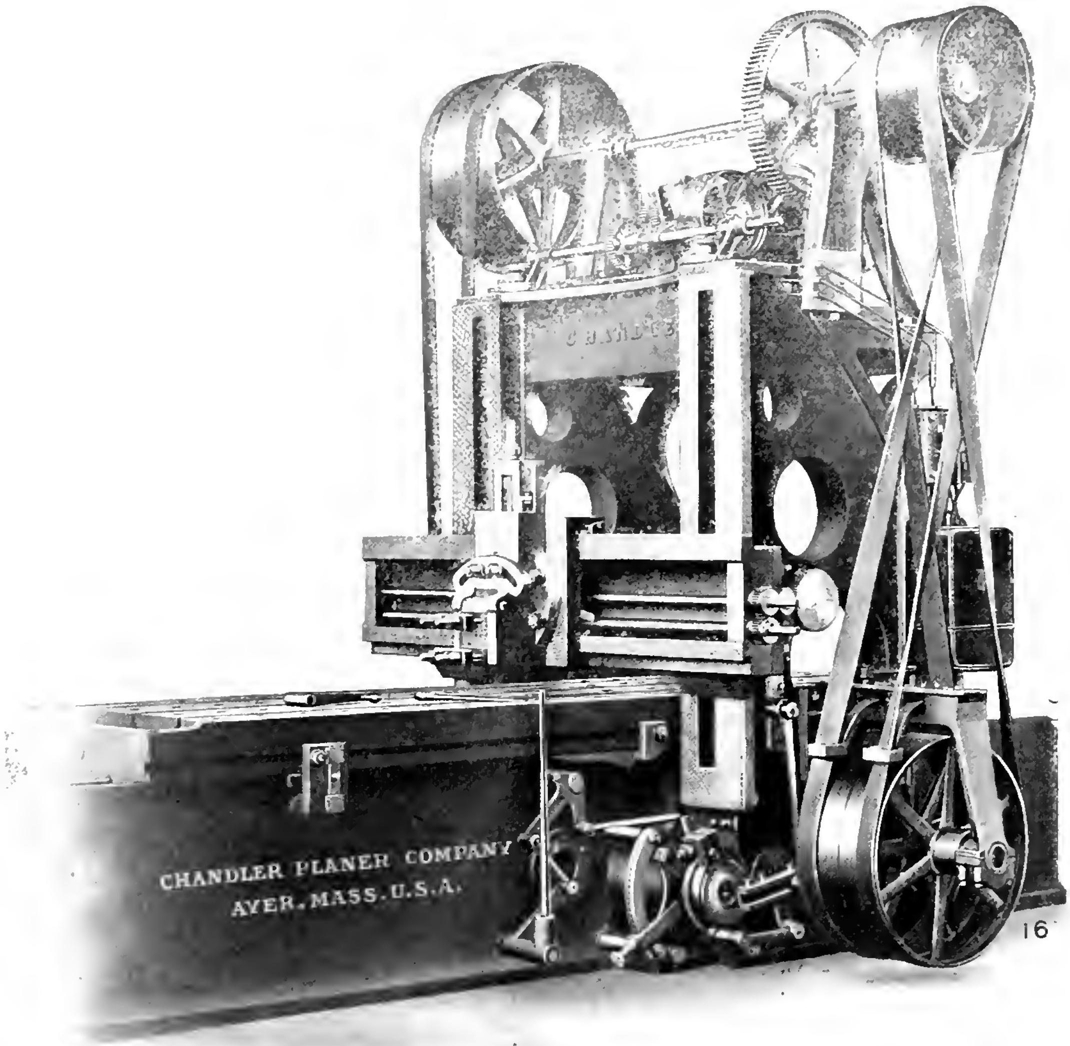
When equalizers are removed from these trucks, the frames will not be supported by blocks on the journal-boxes, but by

COX'S TIME AND COST COMPUTER.



springs. Such a truck is shown in the March issue of THE AMERICAN ENGINEER, under a New York Central car, page 81. There may be some uncertainty as to what kind, and proportions, of springs will be most satisfactory for supporting the frame. The common European practice is to employ long, flat, semi-elliptic springs with small helical springs interposed in the hangers. This arrangement is particularly conducive to easy riding.

The principle commonly employed in equalizing is to group the supports into three sets, the supports of each set being equalized. If there are but two groups the supported load is in unstable equilibrium, and is in danger of being overturned unless some outside influence holds it in position. If the two wheels on each side of a four-wheel truck were really equalized by the equalizer, the truck frame would be tilted by the action of the brakes and by resistance to motion, until the wheel-pieces rested



36-INCH CHANDLER PLANER—WEST ALBANY SHOPS—NEW YORK CENTRAL.

on the journal-boxes. Such would be the behavior of the truck shown in Fig. 1, page 180. But the inequality in the track surface in the length of a truck is so small as to require no equalizing, while the inequalities in the length of a locomotive wheel-base are an entirely different matter.

The six-wheel truck has a longer wheel-base than the four-wheel one, and it has three wheels in line. Equalizers are necessary on it in order to insure the proper distribution of weight on the bearings, and the equalizers here do perform that function. The distribution of weight over six wheels instead of four divides the shocks by six instead of four, and so it will probably be impossible to build a four-wheel truck which will ride as smoothly as the more expensive six-wheel one. But some of the good riding qualities of the six-wheel truck are due to the greater distance between the springs supporting the wheel-piece, preventing the vibrations of the truck frame just as the overhung springs were found necessary on four-wheel electric cars to prevent the vibrations of the body. This is just what would be accomplished by omitting the equalizer of the four-wheel truck and placing the frame-supporting springs over the boxes.

N. O.

WHAT A WESTERN ROAD IS DOING FOR ITS APPRENTICES.

To the Editor:

Have followed articles in your journal regarding the better instruction of shop apprentices, through the organization of special classes for their benefit, with great interest, and thought possibly you might be interested in knowing what the Soo Line is doing in this respect. Although the apprentice of to-day is offered means of bettering himself through the local Y. M. C. A. and private evening classes often conducted by draftsmen, for a small outlay in tuition, these do not seem to be as effective or to meet with such ready response as classes conducted by the railroad company. Such classes also tend to bring the apprentice in closer touch with the railroad organization and give him a better insight into its affairs, thus making him realize to a greater extent his own importance in the organization.

Mr. T. A. Foque, mechanical superintendent of the Soo Line, realizing the importance of bringing the apprentices together in this way, first had an interview with them, trying to make them understand that upon the responsible young man of to-day rests the future success of our railroads. The apprentices in the machine shop, 18 or 20 in number, were organized into two classes, those farthest advanced in their shop term constituting the senior class and the others the junior class. Each class meets every other Saturday afternoon in the drafting room, from one to five o'clock. The head draftsman for an increase in salary, paid by the company, gives them instruction in mathematics and mechanical drawing, also in the process of making prints and filing the drawings for quick and ready reference. The drawing boards, 24 x 36 in. in size, of well seasoned pine and the T-squares of cherry, both made in the company's shops, are furnished by the railroad. The student furnishes his own triangles and instruments. Occasionally an afternoon is devoted to a talk to the apprentices by one of the officials of the motive power de-

partment. The apprentices are very much interested and the plan promises splendid results both for the boys and the company. W. N.

ST. PAUL, MINN.

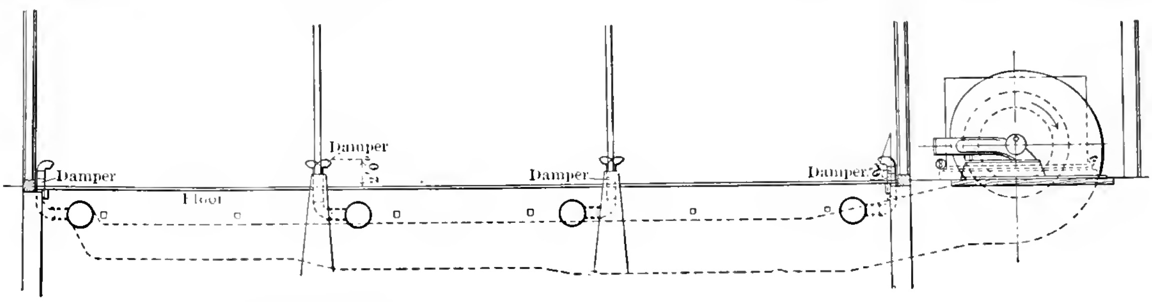
36-INCH HIGH DUTY PLANER.

A 36-inch Chandler planer has recently been installed at the West Albany shops of the New York Central, which has several features of special interest. The greatest difficulty encountered in developing high speed planers has been to secure sufficient belt capacity and, in connection with this, to increase the efficiency of power transmission between the driving belt and the cutting tool. To overcome the difficulty of shifting an extra wide belt two 3-in. belts are used for driving the planer on the cutting stroke. The tight or driving pulley runs between two loose pulleys, the belts being shifted on and off from each side.

Two belts and two sets of pulleys are required for driving the platen on the return stroke. One of these acts as a starter and the other as an accelerator, for instance, the West Albany planer reverses from a 50-ft. cutting speed to a 79-ft. return speed. As soon as the platen is well started on the return stroke the starting belt is shifted off and the accelerating belt is shifted on, increasing the return speed from 79 to 147 ft. per minute. At the end of the return stroke the return belts are operated in the reverse order, *i. e.,* the 147-ft. belt goes off and the slow belt comes on, returning the speed to 79 ft., from which it reverses to the cutting speed.

To reduce the friction in the machine all the shafts are case-hardened and accurately ground, the bearings are made especially long, and the outboard bearings are bushed and have chain oilers. All of the loose pulleys are self-oiling. The gears are of cast steel and the pinion gears and the rack are steel forgings. The planer has two cutting speeds, 30 and 50 ft. per minute; the change from one speed to another is made by means of a back gear in the gear train, somewhat similar to the back gear on an engine lathe. The belt ratios are, therefore increased on the slow cuts, which is a considerable advantage.

The feed is not regulated by the usual wrist pin, which is adjustable on and off the center of the friction box, but by regulating the movement of the friction box with two pins, a fixed pin on the bed of the machine and a pin on the adjustable lever, which moves on a marked dial somewhat as the reversing lever on a locomotive. Any desired feed can, therefore, be had instantly and the position of the levers indicates the amount of feed. The platen may be started or stopped from either side. The 36 in. by 36 in. by 10 ft. planer weighs about 26,500 lbs.



ARRANGEMENT OF HEATER DUCTS AND PIPES—N. Y., O. & W. RY. PAINT SHOP.

HEATING A PAINT SHOP.

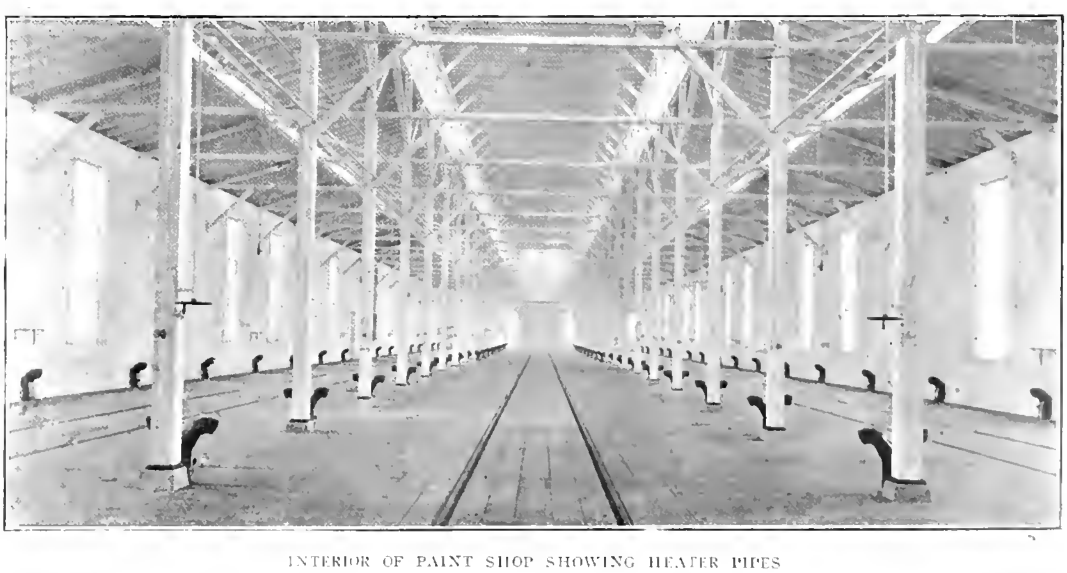
NEW YORK, ONTARIO & WESTERN RAILWAY.

The New York, Ontario & Western Railway has recently completed a new paint shop at Middletown, N. Y., 384 by 66 ft., having three longitudinal tracks. The building is of wooden construction and was designed and constructed under the supervision of Mr. C. E. Knickerbocker, engineer maintenance of way. The method of heating is somewhat different from that ordinarily used in shops of this character, and is of interest. The equipment consists of an 8-ft. fan wheel, which draws the air through a heater, in which are compactly arranged 10 sections containing 6800 ft. of 1-in. pipe. The rapidity of air flow produced by the fan increases the efficiency of the heating surface from 300 to 500 per cent. above that of the same area exposed in still air.

A direct-connected 8 by 12-in. engine drives the fan up to a maximum speed of over 200 r.p.m., which is sufficient to insure a velocity of about 3,500 ft. per min. through the discharge pipe. The heater is designed for the use of high pressure steam, and arranged so that the exhaust from the fan engine may be utilized.

The apparatus is placed in a small lean-to midlength of the main building, this central position reducing the cost of the distributing system to a minimum. Beneath the floor and alongside each of the walls and the column piers run four tile distributing pipes branching from the main brick cross duct from the fan. Branches from these pipes lead to the floor level, the upper portion of each branch being constructed of heavy galvanized iron, and so arranged as to throw the escaping air at an angle toward the floor. This maintains a constantly changing volume of warm air at the floor level, which naturally ascends alongside the painted surfaces of the cars, increasing the rate of drying. The constant replacement of the rising air by the incoming heated volumes insures a fresh warm atmosphere.

The outlets range from 6 to 8 ins. in diameter, and are spaced 16 ft. apart, so that a very uniform distribution and mixing is


INTERIOR OF PAINT SHOP SHOWING HEATER PIPES

secured. Those in the middle of the building are protected from injury by the adjacent columns. The building is warm where warmth is desired—at the floor. The small rooms at the end of the building are heated by the same system through risers extending up from the underground ducts.

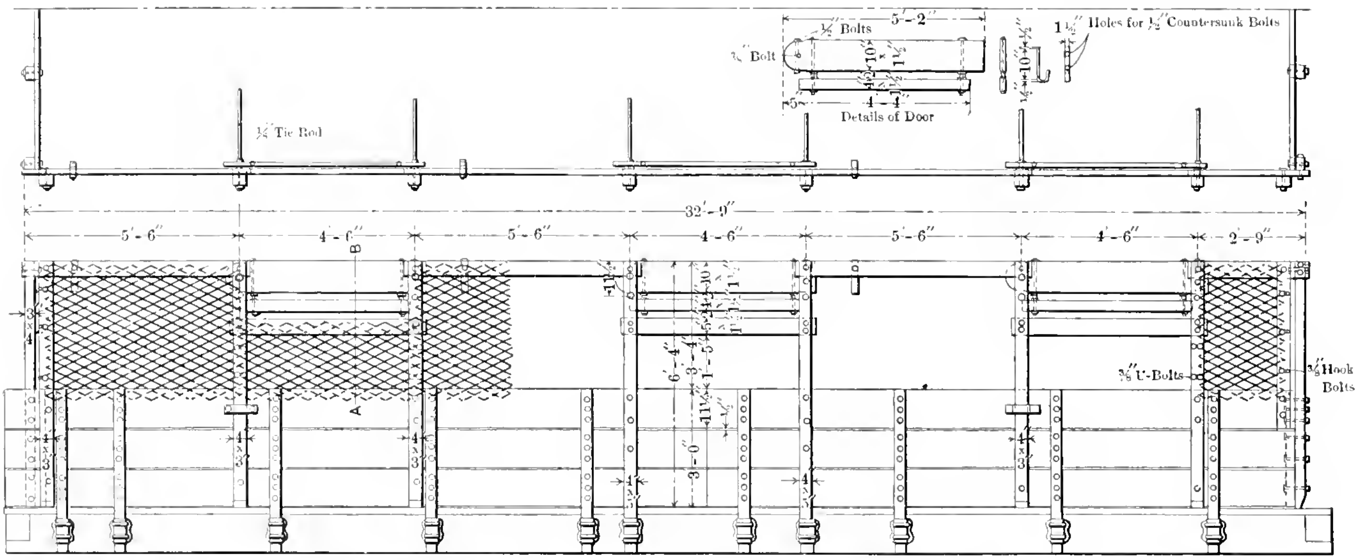
In other arrangements of the blower system the air is distributed through overhead pipes carried upon the roof framing and provided with long discharge pipes extending downward to near the floor. Each method has its advantages, but the results secured at Middletown prove that the underground system gives satisfactory results. The B. F. Sturtevant Company, of Boston, assisted in designing the system and furnished the equipment.

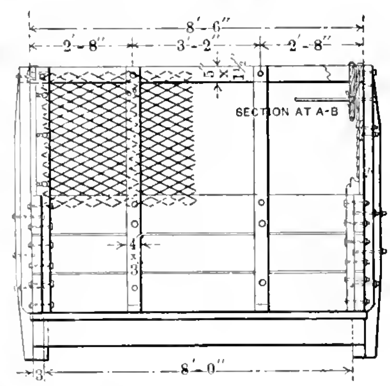
EXPANDED METAL RACKS FOR COKE CARS.

PITTSBURGH AND LAKE ERIE RAILROAD.

The Pittsburgh & Lake Erie Railroad has in service at the present time over 4,000 coke cars, the greater number of which are 30-ton gondola cars which have been converted by the addition of rack is more expensive than wood, and little, if any, saving in weight is effected, it is very much more durable. With cars having wooden sides the laborers at the coke ovens do not hesitate to saw through or break the top of the side if the car is not placed to suit them, or if they think the sides of the car are too high. Damage of this kind, which is usually entirely uncalled for, not only causes a considerable expense to the railroad company, but also causes much inconvenience. This cannot be done where the sides are of expanded metal. The metal used is known as No. 6 gauge, 3 in. mesh, single strand, and is furnished by the Central Expanded Metal Company of Pittsburg.

The stakes, or posts, which support the racks are bolted to the side and end planks of the car, and are tied across the car by ⅞-in. rods. These posts are 4 in. wide by 3 in. thick, except the two nearest the center of the car, which are 4 x 5 in. and which, in addition to being bolted to the side planks, are fitted to stake pockets on the side sill. The 5 x 1½-in. timbers at the top of the sides are bolted to the posts. The expanded metal is fastened at the top and bottom by ¼-in. staples and at the sides by staples and by the ⅜-in. U-bolts and ⅜-in. hook bolts,

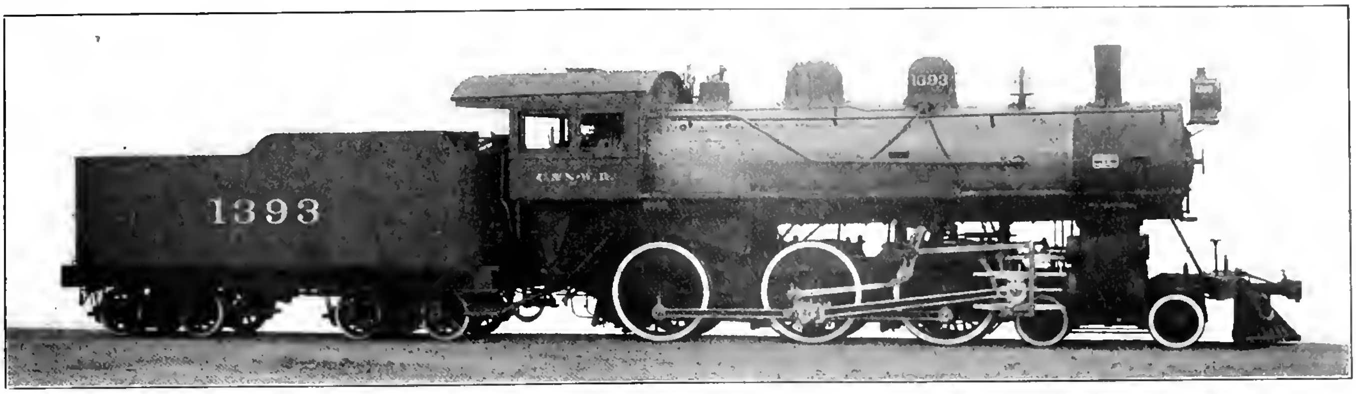




EXPANDED METAL RACKS FOR COKE CARS—P. & L. E. R. R.

of wooden racks. The use of wood for this purpose has, however, recently been discontinued in favor of expanded metal, as shown on the illustrations. While the first cost of this form as shown. The side doors and the method of fastening them is shown in detail on the drawing.

AIR BRAKES ON MOUNTAIN GRADES.—I am of the opinion that where cars are equipped with the improved quick service, retarded release, triple valve and "three-position" retaining valves, no difficulty should be experienced in successfully handling 100,000 pound capacity cars, fully loaded, down approximately 200-ft. grades, providing the brakes are properly maintained and the braking power is, at least, 80 per cent. to 85 per cent. of the light weight of the car.—*Mr. T. L. Burton, before the Air Brake Association.*



SIMPLE TEN-WHEEL LOCOMOTIVE WITH WALSCHAERT VALVE GEAR—CHICAGO & NORTHWESTERN RAILWAY.

SIMPLE TEN WHEEL LOCOMOTIVE.

CHICAGO & NORTHWESTERN RAILWAY.

The locomotive equipment of the Chicago & Northwestern Railway differs from that of probably every other large railway in this country, in that it includes no locomotives of the consolidation type. The work usually performed by that type is taken care of on this road by ten-wheelers, of which there are now 230 in service. In addition to handling heavy freight trains they are also available for use on fast freight or passenger trains, and are largely used for those services.

Recently in increasing this equipment by an order of 30 locomotives from the American Locomotive Company, it was specified that five of the order should have the Walschaert type of valve gear, and it is this design which is shown in the accompanying illustrations and tables. The other twenty-five locomotives of the order do not differ in any essential way from those already in service.

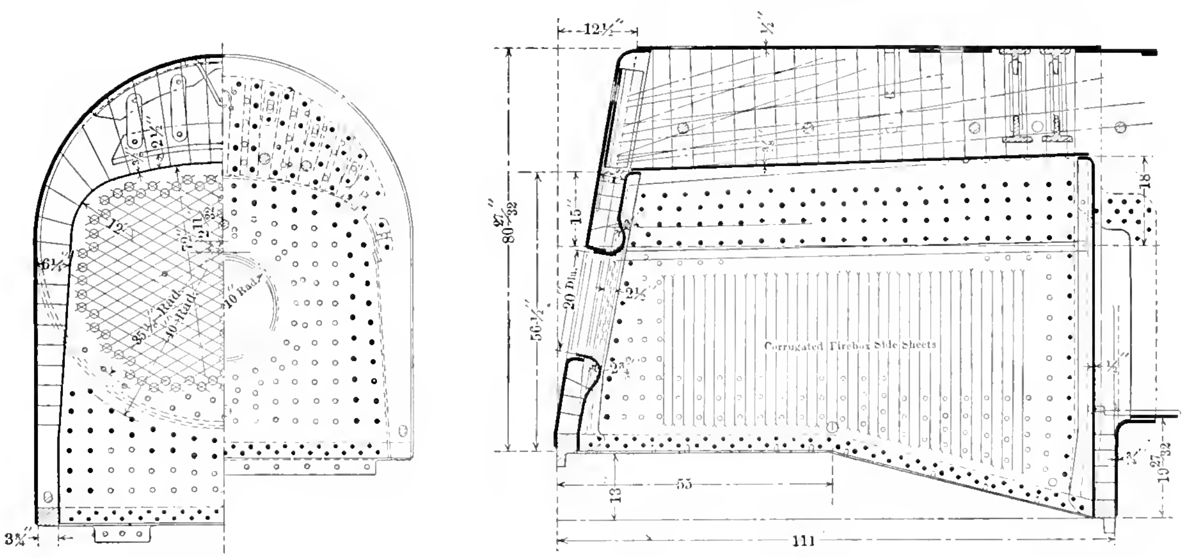
An examination of the list of general dimensions will show the general features of these locomotives. It will be seen that while the boiler is not particularly large, the ratios between the heating surface and cylinder volume and the weights, total, and on drivers, are well within the usual range for this type of locomotive. Furthermore, the specification of identically the same boiler on this last order clearly indicates that it has sufficient capacity for the service demanded which, as mentioned above, may be anything from fast passenger to slow freight. A table is also given by which comparison can be made with three other recent designs of the same type, two on western roads and one on an eastern road. In considering this table it should be remembered that a sufficient boiler capacity on a locomotive depends very largely on the contour of the line over which it operates and on the schedule demanded.

The points of special interest in this design are found in the fire-box and in the arrangement of Walschaert valve gear. The fire-box is fitted with side sheets having vertical corrugations extending nearly to the edge of the sheets top and bottom, and also with the O'Conner fire-door flange. This type of fire-box side sheet has been in use on the C. & N. W. Ry. for the past three or four years with very satisfactory results. We understand that in the same service a sheet of this type will outlast the usual straight sheet by from one to two years. Its advantage, of course, lies in its flexibility in the longitudinal direction which distributes the strains due to expansion and contraction over the whole sheet instead of concentrating them at the flanges. The

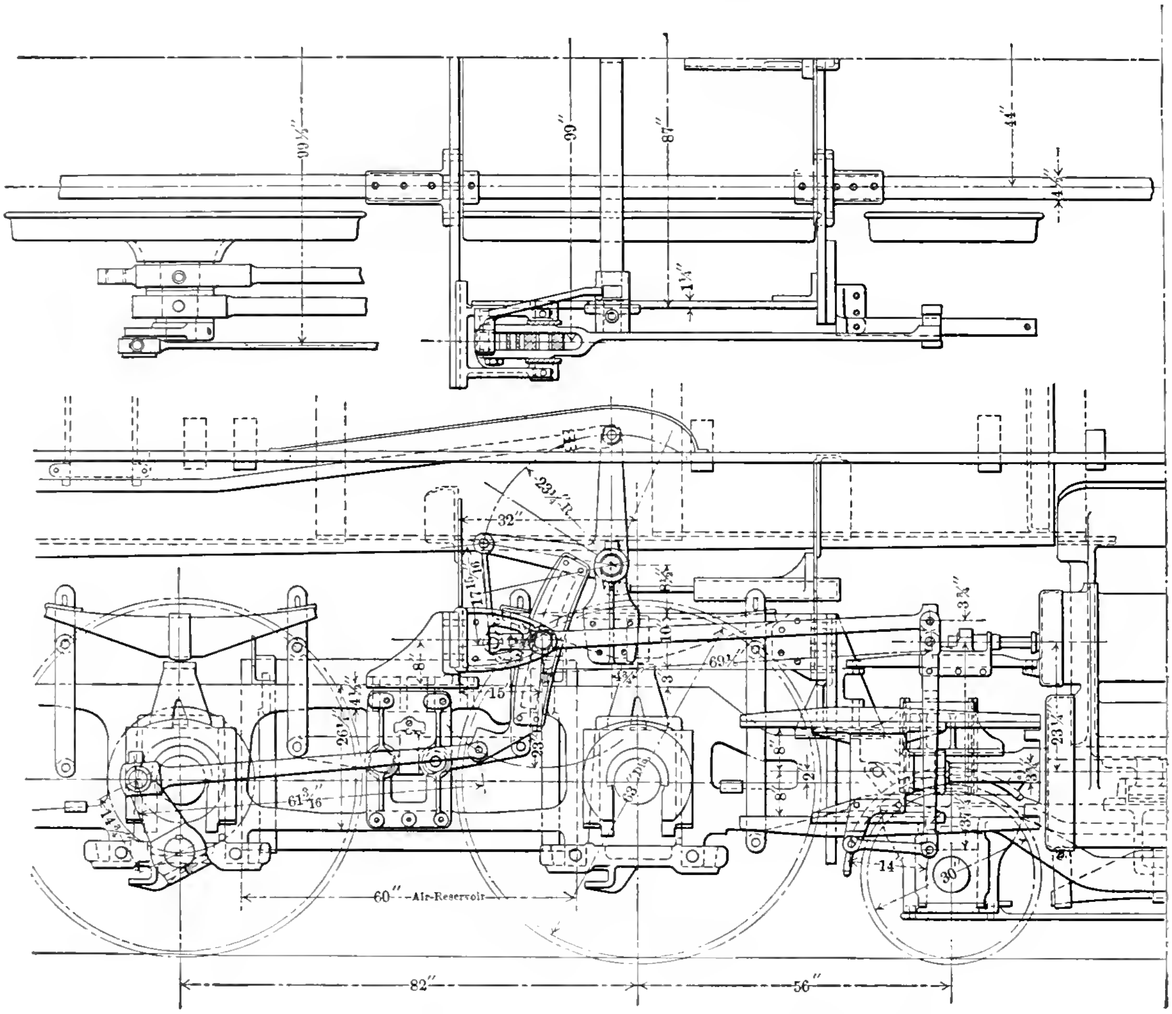
Name of road	N. Y. C.	Frisco	C. R. I. & P.	C.& N.W.
Total weight lbs.	194,500	183,000	173,720	179,500
Weight on drivers, lbs.	148,000	136,000	131,200	135,500
Diameter of drivers	69″	69″	63″	63″
Diameter of boiler	70⅝″	66⅜″	68″	66⅜″
Length of flues	14′ 11″	15′ ½″	14′ 2″	16′ 0″
Flue heating surface, sq. ft.	3,124	2489 7	2,426	2808.4
Firebox heating surface, sq. ft	203	164.6	160.8	150.8
Total heating surface, sq. ft.	3,327	2654 3	2586.8	2959.2
Cylinder volume, cu. ft.	11.4	10.4	11.4	10.4
B. D. factor	642	735	763	655
Wgt. on drivers ÷ total heat surf.	44.5	51.1	50.6	45.8
Wgt. total ÷ total heat surf.	58.7	69.	67.	60.5
Total heat surf. ÷ cyl. vol.	292.	255.	228.	285.
Total heat surf. ÷ grate area	60.5	55.8	46.8	64.
Equated heating surface	1010.	806.6	849.	850.8

staybolts are secured to the bottom of the corrugations in the fire-box and the ends are thus somewhat protected from direct action of the flames.

The O'Conner fire-door flange is simply a design which gives the flange at this point a much larger radius and largely increases the space around the fire-door ring or joint. The larger radius acts in a manner similar to the corrugated fire-sheets by increasing the flexibility of the sheet and preventing the concentration of the stresses at the joint or sharp flange. The reversal of stresses at this point is particularly severe, due to the rapid cooling of the sheets whenever the door is opened. The increased water space around the door largely prevents the collec-



FIREBOX SHOWING CORRUGATED SIDE SHEETS AND O'CONNOR FIRE DOOR FLANGE—C. & N. W. RY.



ARRANGEMENT OF WALSCHAERT VALVE GEAR—CHICAGO & NORTHWESTERN RY.

tion of mud and scale by allowing room for better circulation, and thus prolongs the life of the sheets and the joint. This type of fire-door flange has been in use on the C. & N. W. for several years, and we understand has greatly reduced the trouble formerly experienced in the cracking and burning of the sheets at the door ring. The same design of flange was also specified on the very large consolidation locomotives recently built for the Delaware and Hudson Company by the American Locomotive Company, which were illustrated on page 22 of the January, 1907, issue of this journal.

As was mentioned on page 104 of the March issue, in connection with a description of a ten-wheel locomotive for the Frisco, the application of the Walschaert valve gear to this type of locomotive presents difficulties not encountered on other types. This is due to the location of the guide yoke preventing the attachment of the link in the usual manner, and the introduction of too long a radius bar and too short eccentric blade if it is placed back of the front driver. In the design above mentioned this difficulty was overcome by the use of a heavy extension casting fastened to a heavy steel cross tie across the frames back of the front driver, in which the reverse shaft bearing was also made. The connection to the radius bar was made by a sliding joint. In the present case the arrangement is very similar, except the location and attachment of the reverse shaft. A steel plate 1½ in. thick and 10 in. deep extends between the guide yoke and the steel cross tie, outside the front driving wheel, and supports the reverse shaft bearing. The connection to the radius bar is made by a link in the usual manner. The detailed illustration shows this construction very clearly.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight and Passenger
Fuel	Soft Coal
Tractive power	30,900 lbs.
Weight in working order	179,500 lbs.
Weight on drivers	135,500 lbs.
Weight on leading truck	44,000 lbs.
Weight of engine and tender in working order	319,000 lbs.
Wheel base, driving	14 ft. 10 in.
Wheel base, total	25 ft. 10 in.
Wheel base, engine and tender	57 ft. 9 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.38
Total weight ÷ tractive effort	5.80
Tractive effort × diam. drivers ÷ heating surface	655.00
Total heating surface ÷ grate area	64.00
Firebox heating surface ÷ total heating surface, per cent	5.10
Weight on drivers ÷ total heating surface	45.75
Total weight ÷ total heating surface	60.50
Volume both cylinders, cu. ft.	10.40
Total heating surface ÷ vol. cylinders	285.00
Grate area ÷ vol. cylinders	4.45

CYLINDERS.

Kind	Simple
Diameter and stroke	21 × 26 in.

VALVES.

Kind	Piston
Diameter	11 in.
Greatest travel	5¾ in.
Outside lap	1 in.
Inside clearance	1/16 in.
Lead in full gear	3/16 in.

WHEELS.

Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	9 × 12½ in.
Driving journals, others, diameter and length	8½ × 12½ in.
Engine truck wheels, diameter	30 in.
Engine truck journals	6 × 10 in.

BOILER.

Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	63⅜ in.
Firebox, length	102⅛ in.
Firebox, width	65¼ in.
Firebox, water space	4 in.
Tubes, number and outside diameter	337—2 in.
Tubes, length	16 ft.
Heating surface, tubes	2,808.4 sq. ft.
Heating surface, firebox	150.79 sq. ft.
Heating surface, total	2,959.19 sq. ft.
Grate area	46.27 sq. ft.
Smokestack, diameter	14 and 16½ in.
Smokestack, height above rail	14 ft. 11¾ in.

TENDER.

Tank	Waterbottom
Frame	13" Channels
Wheels, diameter	33 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	7,500 gals.
Coal capacity	10 tons

METAL SAWING MACHINE.

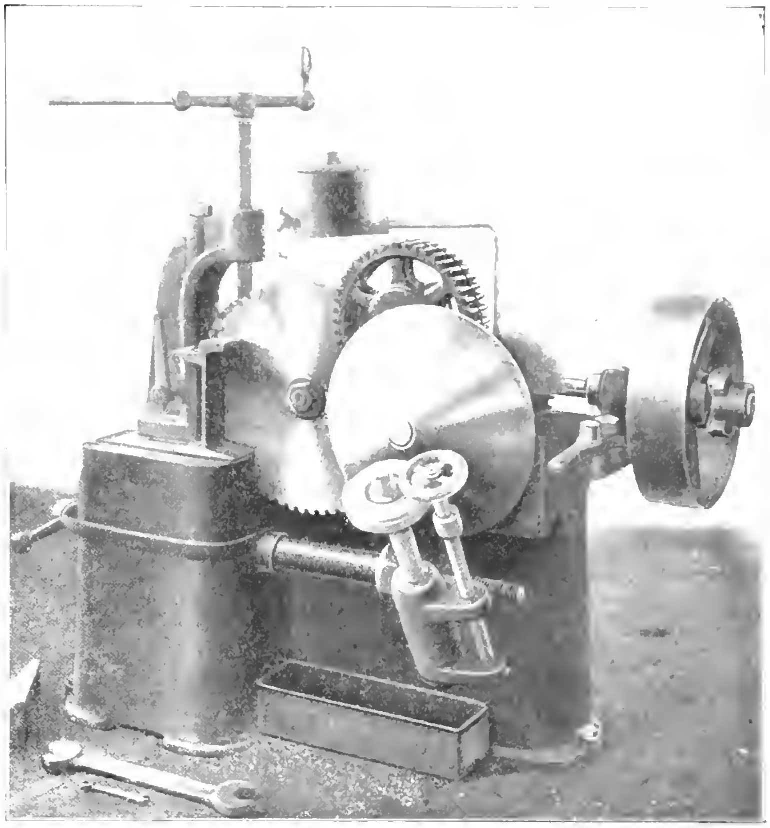
The Quincy, Manchester, Sargent Company has recently placed on the market a metal sawing machine somewhat smaller than their standard machines, but which has a capacity for 6-in. rounds and squares, and 10-in. I beams. The saw blade is driven from the periphery, but by an entirely new method. In place of the sprocket drive, hardened and ground steel rollers are used, journaled in removable steel bushings, which are held securely in the double driving gear. With this arrangement a much larger portion of the blade is available for cutting than with a blade of the same size arbor driven, where about one-third of the diameter is occupied by driving collars. It is also more economical as to repairs, since a worn or broken roller can easily be replaced.

A radial T slot is cast in the side of the carriage and the double gear containing the driving rollers is journaled on a stud held in this T slot. To adjust the driving mechanism when the saw blade becomes worn it is only necessary to loosen the stud and lower the double gear. The table is large enough to enable beams and channels to be properly supported when being cut off at any angle up to 45 degrees. The distance the top of the table is placed below the axis of the saw blade is about one-half the height of the largest shape the machine will cut, and such a piece can, therefore, be placed advantageously for cutting off with a minimum travel of the blade.

The feed is of the variable friction type, is adjustable while the machine is in motion and may be varied from 3/16 in. to 1 in. per minute. It is powerful and continuous in its action throughout the range and is superior to the ratchet feed, which is intermittent.

The general dimensions and data for this machine are as follows:

Diameter of saw blade	18 in.
Thickness of saw blade	3/16 in.
Travel of saw blade carriage	10 in.
Speed per minute of blade	35 ft.
Cutting feed per minute	3/16 in. to 1 in.
Maximum depth of cut	6¼ in.
Capacity, rounds and squares	6 in.
Capacity, I-beams vertical	10 in.
Height from table to saw axis	5 in.
Length of table	14 in.
Width of table	18 in.
Weight on skids, approximate	1500 lbs.

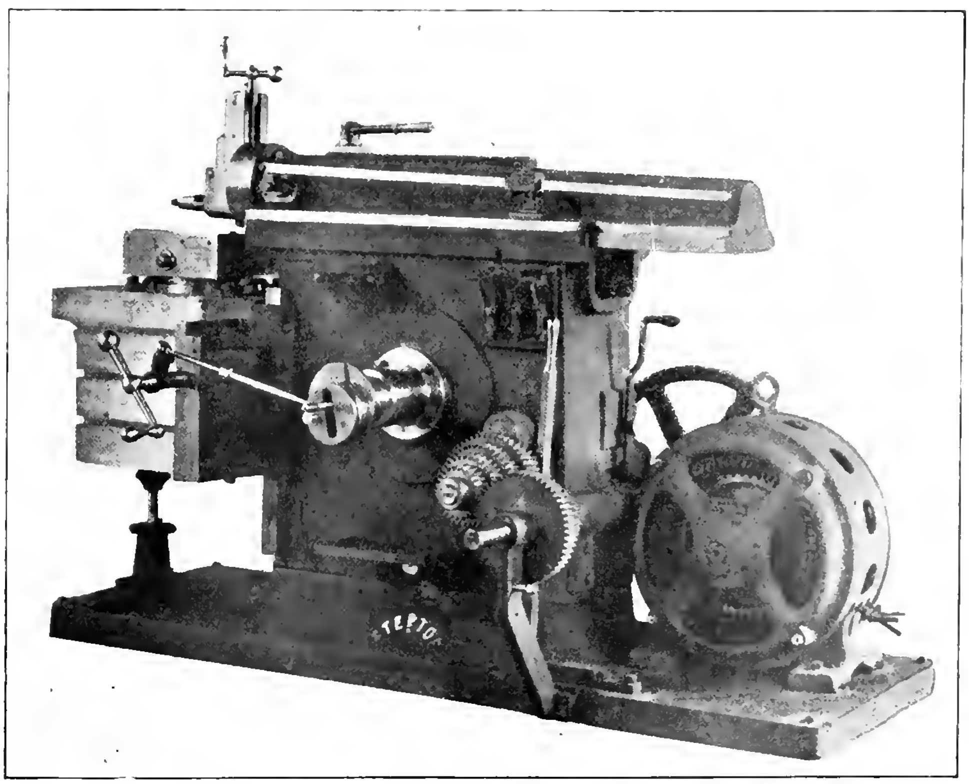


IMPROVED METAL SAWING MACHINE.

The machines may, if desired, be furnished with a motor drive.

25-INCH BACK GEARED CRANK SHAPER WITH SPEED BOX.

The John Steptoe Shaper Company, Cincinnati, O., has recently placed on the market a new line of motor driven back geared crank shapers equipped with a simple speed box, which furnishes four changes of speed. The 5 h.p. constant speed motor is direct connected by means of a small pinion which meshes with the large gear, part of which may be seen at the rear in the illustration. The speed box is shown with the cover removed, and consists of four sets of gears on the two shafts. The gears have exceptionally long bearings, making them rigid and insuring long life. The speed box is operated by the hand lever, which controls a clutch that engages or releases the different gears. The lever at the back of the machine operates the back gears, which in conjunction with the speed box furnish eight changes of speed.



25-INCH CRANK SHAPER WITH SPEED BOX.

The machine is equipped with a power down feed of simple construction, operated by a friction box in connection with a suitable ratchet and bevel gearing. The table support has a roller at the top which comes in contact with a planed surface on the bottom of the table, thus making it possible to take very heavy cuts without springing the

table, and insuring a high degree of accuracy under the most severe conditions. These machines are made in three sizes, 16, 20 and 24 in., the above features being applied to plain as well as back geared shapers.

THE FAVORITE REVERSIBLE RATCHET WRENCH.

The reversible ratchet wrench, shown in the illustration, is manufactured by Greene, Tweed & Company, 109 Duane street, New York, and is made in four sizes. The handle for the smaller size is 15 in. in length and for the other three sizes, 28 in.; as may be seen, it is in one piece, the reversing mechanism being near the head. The heads are made to accommodate square nuts on one end and hexagon on the other, or hexagon nuts on both ends, and are constructed so that there is a clear opening through them, allowing the bolts to pass through. The small size takes three different heads, the second size five and the third and fourth sizes three heads each. The openings in

FAVORITE REVERSIBLE WRENCH, HEADS AND SOCKETS.

all the regular size heads are designed to fit standard nuts. Ordinarily only one head is furnished with the wrench, but as many of the others may be ordered as desired. Heavy extension sockets 10 in. long for ¾-in. square and hexagon nuts may be furnished to fit one of the heads of the second size wrench.

The advantages of this wrench are that its motion is continuous until the nut is seated or removed, thus economizing time; it entirely encompasses the nut, thus preventing slipping and marring; it can be used in a limited space, as a very slight travel of the handle will catch one tooth of the ratchet; the motion can be instantly reversed by slipping the pawl one way or the other, and there is very little machine work on it, thus minimizing its cost. They are used extensively on several large railroads.

Mr. John E. Ward, vice-president of the Gold Car Heating & Lighting Company, has decided to retire from the management of the Gold Companies for the purpose of engaging in the business of manufacturing and dealing in railway, steamship and contractors' supplies. About July 1st he will start on an extended trip abroad, and on his return will open offices in New York City. Mr. Ward, who has been actively engaged for a number of years in the railway supply business, was born at Poughkeepsie, N. Y., on June 3, 1875, receiving his early education in the public and high schools of that city, and in 1891 graduated from Manhattan College, New York City. He advanced rapidly from the duties of chief clerk, shop superintendent, sales agent and general manager to the position of vice-president of the Gold Companies.

The Alternate-Current Motor is particularly applicable to this class of work (planing mill) on account of its inherent characteristics and sparklessness, which latter is particularly valuable in the inflammable atmosphere.—*Mr. G. R. Henderson at the New England Railroad Club.*

PERSONALS.

Mr. E. A. Wescott has been appointed assistant mechanical superintendent of the Erie R. R., with office at Meadville, Pa.

Mr. B. Tarkington has been appointed road foreman of engines and equipment of the Midland Valley R. R. at Muskogee, I. T.

Mr. M. Parra has been appointed master mechanic of the Tampico terminal, Mexican Central Ry., succeeding Mr. A. G. Kirchner, resigned.

Mr. R. L. Stewart, general foreman of the Kansas City Southern Ry., has been appointed master mechanic at Pittsburg, Kan., succeeding Mr. W. B. Dunlevy.

Mr. R. C. White has resigned as master mechanic of the Birmingham Southern R. R. to accept a similar position with the Birmingham Rail & Locomotive Co.

Mr. M. F. Beuhring has been appointed foreman of the car shops of the International & Great Northern Ry. at Houston, Tex., in place of Mr. Martin Ryan, resigned.

Mr. W. H. Maddocks has been appointed assistant superintendent of machinery and equipment of the Missouri, Kansas & Texas Ry., with headquarters at Parsons, Kan.

Mr. P. J. Colligan has been appointed acting master mechanic of the Chicago, Rock Island & Gulf Ry. at Fort Worth, Tex., succeeding to the duties of Mr. J. E. Holtz, resigned.

Mr. R. M. Boldridge, formerly master mechanic of the Mississippi Central R. R., has been appointed master mechanic of the Central R. R. of Georgia, with headquarters at Cedartown, Ga.

Mr. C. A. Snyder, heretofore master mechanic of the Gulf, Colorado & Santa Fe Ry. at Cleburne, Tex., has been appointed master mechanic of the El Paso & Southwestern R. R. at Douglas, Ariz.

Mr. A. C. Adams has been appointed master mechanic of the Alliance division of the Chicago, Burlington and Quincy Ry., with office at Lincoln, Neb., succeeding Mr. G. M. Reynolds, resigned.

Mr. E. E. Austin has been appointed master mechanic of the third district of the Can. Pac. Ry., with headquarters at Nelson, B. C. The position of road foreman of the third district has been abolished.

Mr. W. H. Sitterly has been appointed general car inspector of the Buffalo & Allegheny Valley division of the Pennsylvania Railroad at Buffalo, N. Y. Mr. Sitterly succeeds Mr. S. M. Hindman, promoted.

Mr. Frederick Mertsheimer, formerly sup't. of mach. of the Kansas City Southern R. R., has been appointed sup't. of the motive power and car departments of the Kansas City, Mexico & Orient Ry., with headquarters at Sweetwater, Tex.

Mr. William Miller, formerly master mechanic of the Denver & Rio Grande Ry. at Denver, Colo., has been appointed superintendent of motive power of the Western Maryland R. R., with headquarters at Union Bridge, Md., succeeding Mr. I. N. Kalbaugh, resigned.

Mr. William O'Herin, sup't. of machinery and equipment of the Missouri, Kansas & Texas Ry., has been given indefinite leave of absence to recover from injuries sustained some months ago.

Mr. Geo. H. Daniels, after a service of about twenty years with the New York Central and Hudson River R. R., has retired from active management of the advertising department of that road, of which he has been in charge during the past year. Previous to that time he was for many years general passenger agent of the system. Mr. Daniels is said to have more and better friends than any other railroad man in the country. He is possessed of a rare amount of tact and has an enviable reputation for resourcefulness and skill in handling difficult problems and situations. He was born December 1, 1842, in Hampshire, Ill., and entered the railroad business at the age of 15 as a rodman.

BOOKS

Table of Volumes Through Air Ways. By C. H. Kuderer. Cardboard, 8 x 11 in. Published by E. E. Meyer, Allegheny, Pa. Price, $0.25.

This table gives the volume of air passing through air ways of different lengths from 1,000 to 11,000 ft. with areas from 1 x 1 ft. to 10 x 10 ft. with increments of 6 in. and under different pressures varying by tenths of an inch, from one-tenth to two and five-tenths in. W. G. It will be found to be a most valuable and convenient reference for engineers who meet with problems of air transmission through large air ways.

Locomotive Engine Break Downs and How to Repair Them. By W. G. Wallace. 282 pages. 4½ by 6¾. Bound in flexible leather. Published by Frederick J. Drake & Co., Chicago. Price, $1.50.

This book contains nearly 400 questions that have been asked by enginemen and answered by Mr. W. G. Wallace through the columns of the *Brotherhood of Locomotive Firemen's Magazine.* They cover almost every possible breakdown and include many difficult problems, all of which are answered in a clear-cut manner and in simple terms. Many illustrations are included, materially assisting in giving a clear explanation of the proper procedure in any particular case. This is a very valuable collection of information, and is carefully indexed for rapid reference.

Standard Examination, Questions and Answers. For Locomotive Firemen. By W. G. Wallace. 343 pages. 4½ by 6¾. Flexible leather. Published by Frederick J. Drake & Co., Chicago. Price, $1.50.

This book contains the standard questions adopted by the Traveling Engineers' Association for the mechanical examination of locomotive firemen for promotion. Each question is followed by a full and comprehensive answer, illustrations being included where necessary. These questions cover the progressive examinations for the first, second and third years. In addition to the questions and answers there is much valuable information on the general features of the locomotive and its parts, including valve setting; train resistance; oil burning locomotives; recent air brake practice; chapter on fuel combustion; one on "don'ts," etc. It will be found to be of value to engineers who have already passed their examination, as well as to firemen who are preparing for it.

Engineering Index. Annual. 1906. 395 pages. 6½ by 9½. Cloth. Published by the Engineering Magazine, 140 Nassau St., New York. Price, $2.00.

This book acts as a supplement to the five yearly volume No. 4, which covered the years from 1901 to 1905 inclusive, and brings the index complete down to the end of 1906. In view of the desirability of issuing this annual at the earliest possible moment, it has not been classified alphabetically, as is done in the larger volume, but retains the same scheme of classification used in the monthly numbers of the Engineering Magazine. The scope and character of these indexes is too well known to require comment, and there is no doubt that the issuing of the annual numbers will be appreciated by all engineers who have occasion or desire to look up the most recent articles published on any particular subject. This volume in connection with the previous five year indexes puts in the hands of its possessor a complete catalog of all of the more important technical periodical literature published during the last 23 years.

CATALOGS.

STORAGE OF OILS AND GASOLINE. S. F. Bowser & Company, Fort Wayne, Ind., is issuing several catalogs describing their system of storage and handling of gasoline, lubricating and illuminating oils.

CRANE SPECIALTIES.—The Crane Company, Chicago, is issuing a very complete little catalog of valve fittings and appliances for every purpose and all pressures. Each valve, etc., is illustrated by parts and sections and is accompanied by a brief description.

ELGIN & BELVEDERE ELECTRIC RAILWAY.—The Arnold Company, 181 La-Salle Street, Chicago, is issuing Bulletin No. 17, which contains a complete illustrated description of the above railroad, which is 36½ miles in length, and the construction of which was in the hands of this firm of engineer-contractors from its earliest preliminary stages to its operation.

B. F. STURTEVANT COMPANY.—The above company is issuing bulletin No. 146, which illustrates and describes electric propeller fans. This type of fan is used for ventilation and special attention has been given to its simplicity and reliability of operation. These fans are built in a full line of sizes from 18 in. to 120 in. and are driven by a type of motor which is absolutely dust proof. The fan may be placed in any location and controlled by a switch from a distance.

MALLEABLE IRON JOURNAL BOXES.—The Gould Coupler Company, 1 W. 34th street, New York, is issuing part catalog No. 3 on the subject of malleable iron journal boxes. These boxes are clearly illustrated and thoroughly described. A flexible type of dust guard, which will permit the applying of a new guard without removing the box from the journal, is used with these boxes, which also include a number of other improvements. There are at present over a million of this type of box in service.

NEW G. E. BULLETINS.—The General Electric Company, Schenectady, N. Y., is issuing several new bulletins as follows: No. 4394B illustrates and describes form P belt driven alternators. No. 4494 is on the subject of incandescent lamps with Holophane reflectors. No. 4497 is on the subject of snap sockets. No. 4500 is on the subject of constant current transformer panels. The same company is also issuing a convenient table which shows the approximate size of wires for three-phase transmission lines.

ELECTRICAL APPARATUS.—The Fort Wayne Electric Works, Fort Wayne, Ind., is issuing several new bulletins illustrating and describing recent designs of electrical apparatus. No. 1,086, which supersedes 1,026, deals with direct current, series, enclosed, arc lamps. No. 1,091, superseding 1,036, describes direct current motors. No. 1,092, which supersedes 1,072, is on type S single phase motors, and No. 1,093, which supersedes 1,071, is on the subject of small power motors, from 1/100 to 1/30 h. p. capacity.

TATE FLEXIBLE STAYBOLTS.—The Flannery Bolt Company, Pittsburg, Pa., is issuing a leaflet regarding the installation, inspection and testing of its type of flexible staybolt. It explains in detail the proper method of installing the bolts in the boiler and what points need inspection. Methods of securing the lagging to the jacket in sections, so as to allow ready inspection, are explained, as well as what testing should be given the bolt after its application. It is stated that over one million of this type of bolts are now in use on 88 different railroads.

ELECTRIC LIGHT FOR POSTAL CARS.—The Consolidated Railway Electric Lighting & Equipment Company, 11 Pine street, New York, is issuing Bulletin No. 5 descriptive of the "axle light" equipment for postal cars. A special type of this equipment has been perfected particularly for these cars, which require better and more reliable light than any other part of the train. The electric light is particularly well adapted for this purpose on account of its flexibility of location and greater safety. The catalog contains illustrations of cars and apparatus, and also includes wiring diagrams with complete descriptive matter.

ROTARY SNOW PLOW.—A pamphlet recently issued by the American Locomotive Company illustrates and describes the rotary type of snow plow built by that company. The first part of the pamphlet contains a brief account of the work done by the rotary in fighting the snow on various railroads, with illustrations showing it in operation. Then follows a description of the plow, giving the particular features of the design. The last part of the pamphlet contains a set of rules for the guidance of those operating the rotary, which are based on experience gained during the past years in handling the plow.

TARVIA.—The Barrett Manufacturing Company is issuing a small catalog describing the above product, which is a coal tar preparation for roads and boulevards, making them smooth, compact and absolutely dustless. The method of application is clearly explained and many illustrations of roads, both in the city and country, which have been treated are shown.

A FEW POINTS ON GRINDING.—The Norton Grinding Company, Worcester, Mass., is issuing a booklet with the above title, which will be found to be of much practical benefit to those who have grinding to do. This company is undoubtedly in a position to speak with great authority on the subject and this booklet is full of valuable hints for the successful and economical operation of grinding machines of different types.

A STUDY IN GRAPHITE.—The Joseph Dixon Crucible Company is issuing a booklet with the above title, which gives in detail a series of tests of graphite as a lubricant made by Dr. W. F. M. Goss of Purdue Universtiy. The study opens with a dissertation by Dr. Goss based upon the conclusions drawn from the tests; then follow complete description of the tests, together with illustrations of the testing machine and of the condition of the bearings and journals taken at different stages. A limited number of copies of this book will be distributed free to those interested in the science of graphite lubrication. Upon the exhaustion of these a charge of 25 cents per copy will be made.

GISHOLT LATHES.—The Gisholt Machine Company, Madison, Wis., some time ago purchased the drawings, patterns, etc., of the American Turret Lathe Mfg. Co., who were the manufacturers of the American semi-automatic turret lathe, a machine exceedingly well adapted for the finishing of certain classes of work, such as gear blanks, cylinder heads, fly wheels, pulleys, etc., and is issuing a very attractive catalog devoted to it. The machine is exceedingly powerful and massive in design, yet is very easily controlled and operated. The company announces that it is in a position to furnish prompt deliveries of this class of machine. The catalog thoroughly illustrates and describes all the important features of these lathes.

PURDUE UNIVERSITY CATALOG.—The annual catalog of Purdue University, Lafayette, Ind., which has recently been issued, includes a very complete description of the material equipment of this rapidly growing University, which now embraces seven special schools, including a school of agriculture, a school of science, schools of mechanical, civil and electrical engineering, as well as of pharmacy and medicine. Complete information is included on the detailed courses given in each of these schools, including a description of each course, showing how much time is given to each and its extent. A chapter is included on the expenses at the University and the catalog is completed by a register of the 2,046 students now in attendance.

RESULTS OBTAINED FROM WATER SOFTENING.—The Kennicott Water Softener Company, Railway Exchange, Chicago, has printed, for private distribution, an attractively arranged booklet, composed entirely of extracts from reports and published articles of disinterested parties concerning the results which are being obtained from water softening on railroads. The extracts are carefully selected, brief and to the point, and must appeal to the busy and practical railroad officer. The book contains only 26 pages, in addition to two large diagrams, and is 5 x 8 ins. in size, so that it can be slipped in a side pocket and studied at leisure moments on the train or going to and from the office. The source of the information is noted in every case, so that those who wish to go into the matter more fully can do so.

THE CARE OF ELECTRIC MINE LOCOMOTIVES IN SERVICE.—The Jeffrey Manufacturing Co., Columbus, Ohio, is issuing bulletin number twelve having the above title. It contains information of great importance to the users of electric mine locomotives in the nature of detailed explanation of the proper method of dismantling, repairing, assembling and adjusting all parts of these machines. The text matter is fully supplemented by illustrations reproduced from photographs and every point is so fully covered as to make mistakes impossible even by a common laborer. The book leaves nothing to be desired in the way of typographical excellence or arrangement, and in addition to the instructions for repairing, contains illustrations and descriptions of many standard locomotives, complete and in detail, regularly manufactured by this company.

DEWEY DECIMAL SYSTEM.—The Engineering Experiment Station of the University of Illinois has recently issued Bulletin No. 9, entitled, "An Extension of the Dewey Decimal System of Classification applied to Engineering Industries." This bulletin is in effect a fifth edition of the extension previously issued by the mechanical engineering department of the University. It contains the extensions previously worked out for railway mechanical engineering and in addition, a very complete extension for electrical engineering, as well as more or less complete extensions for bridge engineering, sanitary engineering, metallurgy and architecture. An alphabetical index of subjects is included. The station is also issuing Bulletin No. 10, giving the results of tests of concrete and reinforced concrete columns, and Bulletin No. 12, on tests of reinforced concrete T beams.

NOTES

MAGNUS METAL COMPANY.—The general offices of the above company have been removed from Buffalo to New York City, and the company will no longer maintain an office in the former place. Quarters have been obtained in the Trinity Building, 111 Broadway.

BLISS ELECTRIC CAR LIGHTING CO.—Among the orders recently received by the above company, whose general office is at Milwaukee, is one from the Baltimore & Ohio R. R., to light the cars of the Royal Blue limited trains with the Bliss system of electric car lighting.

GENERAL ELECTRIC MOTORS FOR CHICAGO STREET RAILWAYS.—The Chicago City Railways Company has purchased from the General Electric Company, 1,200 direct current railway motors with a controlling apparatus for 300 cars. Each car will be equipped with four 40 h. p. motors. The power for the new rolling stock will be supplied by additional generating machinery, aggregating 6,000 h. p.

"MACHINERY'S" NEW OFFICE.—The editorial and advertising offices of *Machinery* have been moved to the eighth floor of a new building recently erected at 49 Lafayette street, New York. This location is one block east of Broadway and four blocks north of the City Hall. The offices occupy the whole of the eighth floor.

AMERICAN STEAM GAUGE & VALVE MFG. CO.—Mr. Charles H. Glasser, formerly mechanical engineer of the Camel Co., Chicago, has accepted a position with the above company, and will make his headquarters at its Chicago office. Mr. Glasser has had several years' experience in the mechanical field and possesses a very wide circle of friends.

FALLS HOLLOW STAYBOLT COMPANY.—This company announces that the fire which broke out in its plant on the morning of May 9 did not interfere with the operation of the mill to exceed 24 hours, and that the damage resulting was of little consequence and will not interfere with or delay the filling of orders. Within two days the plant was running day and night as usual.

GENERAL ELECTRIC COMPANY.—The San Francisco office of the above company is now permanently located in the Union Trust Bldg., in San Francisco. Since the fire, this office has been located in the Union Savings Bank Building at Oakland, large temporary warehouses having also been erected in the same city.

B. F. STURTEVANT CO.—The New York office of the above company has been removed from 131 Liberty street to the Engineering Building, 114 Liberty street, where much better facilities for conducting its rapidly increasing business have been obtained. This company reports that the past year, in particular, has marked a very great increase in the demand for its machinery of all kinds for installation in New York and vicinity.

THE NORTON COMPANY.—This company, which has works at Worcester, Mass., and Niagara Falls, N. Y., for manufacturing grinding wheels of alundum and other abrasive specialties, is to erect a large addition to its Worcester Works. This will consist of an extension to the plant designated as No. 2 and will more than double its present capacity. The same company also announces a change in the location of its Chicago office, which is now at 48 S. Canal street.

CROCKER-WHEELER MOTORS.—The Tennessee Coal and Iron Company, which recently received the largest order for steel rails ever placed with a single concern, amounting to 150,000 tons and placed by the Harriman Lines, has just ordered from the Crocker-Wheeler Company, of Ampere, N. J., a complete electric motor equipment for its new steel rolling mill at Birmingham, Ala. This order includes 15 C. W. form W. rolling mill motors, aggregating about 575 h. p.

EXHIBIT OF CAR LIGHTING AT ATLANTIC CITY.—The exhibit of the Bliss Electric Car Lighting Co., of Milwaukee, at the Atlantic City Conventions will occupy spaces 1201-1207 on the south side of the Steel Pier. It will consist of complete 30 and 60 volt equipments for electric car lighting, which will be in operation on the pier under the conditions that will closely simulate those encountered in actual service. The exhibit will be in charge of the president, vice-president and general manager of the company.

SILK, MCCLELLAN & COMPANY, incorporated, brings together, in its active management, two young men who have had a wide experience in the supply business and who have a host of friends among railroad men who will be pleased to hear of their new venture. This company, with a factory in Chicago, is manufacturing a line of high-grade railway car specialties. Mr. Edward E. Silk has been in the railway supply business for seven years; previous to that time he was in the employ of the C. R. R. of N. J., and for two years was associate editor of the AMERICAN ENGINEER AND RAILROAD JOURNAL. He is a graduate of the railway mechanical engineering school of Purdue University. Mr. Benj. S. McClellan has been in the supply business for about six years; previous to that time he was for eight years in charge of the car shops of the Illinois Central Railroad at the New Orleans terminal and for three years in charge of the passenger car shops of the New York Central at West Albany. Silk, McClellan & Co. include in their list of specialties a line of dust proof car window fixtures, special sash locks, desk sash ratchets, universal steam couplers and hose bands. The main office and factory of the company is at 58th street and Normal avenue, Chicago. They have complete sets of blue prints and illustrated matter which will be sent on application.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

JULY, 1907

A RATIONAL APPRENTICE SYSTEM.

[Editor's Note.—In the June issue, page 201, we presented the first of a series of three articles on the New York Central Lines apprentice system, which are intended to present in detail the workings of the system and are supplementary to the paper on the same subject presented before the Master Mechanics' Association by Mr. C. W. Cross, superintendent of apprentices, and Mr. W. B. Russell, his assistant.

This is the first apprentice system which has been introduced, on a large scale on a railroad in this country, which has in it the elements that are necessary to adequately meet the present conditions and build up a body of skilled workmen for the future. The great problem before our railroads and manufacturing industries today is not that of better shops and equipment, or even of better methods of operating, but is that of *men*. It can only be solved by improving the organization with a view of bringing the efficiency of each individual worker to the highest possible point and by preparing skilled workmen for the future. The keynote of the situation was sounded in the presidential address of Mr. J. F. Deems before the Master Mechanics' Association, part of which is reproduced following this note.

The paper by Messrs. Cross and Russell was on the program as a topical discussion but it very soon developed that it was the most important subject before the Association, and this meeting will go down in history as the one at which it was considered. One hour was allowed on the program for the presentation and discussion of the paper, but when after over an hour and a half it became necessary to adjourn, it was unanimously voted to devote the noon hour of the following day to it. Never before has this been done.

Two years ago Mr. G. M. Basford stirred the Association by his masterful paper calling attention to the imperative need of installing adequate apprentice systems on our railroads and presenting the outline of a system to meet the present conditions. It must indeed be a matter of great satisfaction to him to see his plans being successfully applied and perfected on the New York Central Lines and to know that other roads have started the work on a smaller scale or are preparing to meet it in a similar way. The railroads cannot thank him too much for the impetus and direction which he has given to this movement.

The discussion was so important that parts of it are reproduced.]

Extract from Mr. Deems' Address.

No war-bronzed veterans ever had deeper inspiration or greater cause for self-forgetful devotion than had the pioneers who bore the brunt of the early days of the development which this Association has so splendidly advanced. All the honors accorded to military achievement in the past, but illy compare with those which the future will gladly erect to the memory of the men who have given us that grander, that more useful development—transportation—without which to-day the world would be largely a waste. Our predecessors met in a small way and singly the problems which we and those who follow us must meet collectively and in a larger sense, and to solve which it will be necessary to form great combinations that must be harmonious, cohesive and permanent. It is no slight task to conceive and build a structure that will provide for the interchange of people, the mutation of ideas and the physical distribution of that which enters into man's every need. We are fortunate in that our fathers built so well, let us hope that those who follow can truly say the same of us; let us devote ourselves seriously to the problems of to-day; the chief among which is to try to do as well the things that come to our hand as our predecessors did with the smaller things that came to their hands.

A legacy has been bequeathed, a legacy for which all preparation has been made, a legacy of opportunity which looms large in the future and awaits with rich reward the man who is prepared—*the man who is prepared.* We have received; what shall we give? We have inherited; what shall we bequeath, what shall we leave to aid in solving the problems of the future, many of which may be much more perplexing than those we are called upon to solve to-day? We may work in brass and steel, and leave the most perfect mechanism—we may develop and improve and evolve methods and practices until nothing more can be desired—we may reach perfection in all these, in mechanism, structure and method, and yet our bequest be a failure and itself a burden unless we provide that which is paramount, which is over and above the sum total of all of this, and for which, even to-day, events throughout the world are crying aloud—*the man. A man prepared, experienced, earnest, hopeful and happy, consecrated to his work and ready to give the hand to the future.*

This, my friends, as I see it, constitutes our greatest opportunity, our most imperative, our most sacred duty. If the man is provided, the machine will cease to be a burden and methods will come forth as the buds at the kiss of spring. *Our own future, and the hope of that larger future which lies beyond, depends on our efforts and our success in providing those who are to help us to-day, and upon whom at no distant day must fall our duties, our opportunities, our honors and our failures.* Have we any greater, grander, more sublime obligation than this? Can we justify a pride in our life-work, if we fail in this? If I can but bring to you this single message, if I can inspire you with this one thought, I am content.

The Apprentice System on the New York Central Lines.

By Messrs. C. W. Cross and W. B. Russell.

The object of this paper is to present briefly the main features of a plan, already in successful operation on a large scale, which aims to meet a genuine need in a direct and common-sense manner, a plan worked out primarily to meet the specific needs of a particular group of shops, yet based on general principles that will make it workable anywhere.

Purpose.—The purpose of the apprentice system is to provide the motive power department with an adequate recruiting system which will eventually produce from the ranks a large number of skilled workmen, a number of foremen, a sufficient number of good draftsmen, a few master mechanics and an occasional superintendent of motive power.

The subject of an approved apprentice system has long been a favorite scheme of Mr. J. F. Deems, and was first mentioned by him on the New York Central Lines in December, 1902; it was not until March 1, 1906, however, that arrangements could be made to inaugurate the plan. At that time the authors of this paper were engaged to take charge of the work. The first apprentice class under this plan was started at the West Albany shops, May 7, 1906. Much of the general idea and many of the details have been worked out in conformity with the suggestions made in a paper on this subject by Mr. G. M. Basford, read before this Association at the 1905 convention. Mr. Basford expressed the necessity for this work in these words: "The engineering and the operating situation on railroads is in advance of its men, and in many ways the problem has outgrown both the individual and methods of dealing with the individual, and especially has it outstripped methods of preparing men for their work."

Plan—Trade and Educational.—The general plan is twofold, and provides for shop instruction of the apprentice in the trades and also for his instruction in mechanical drawing, practical mathematics and shop problems during working hours while under pay.

Inauguration.—A department headquarters was first organized to outline the courses of instruction and to prepare the necessary instruction sheets and text-books. Two instructors—a shop instructor and a drawing instructor—were then appointed at each of the larger shops; a uniform set of apprentice regulations was adopted for all shops and a schedule provided showing the time allotted in the shop to each class of work. This schedule is sufficiently flexible to insure a prompt movement of the apprentices from one class of work to another and to still leave opportunity for rapid movement in case of special merit. Both the shop instructors and the drawing instructors are under the local shop officers and responsible directly to them. Regular reports are made by both instructors to their immediate superiors, who forward them to the apprentice headquarters. In the educational work, however, the instructors are kept in direct touch with the apprentice department.

Difficulties.—There are really no serious difficulties, except that

of securing the thorough and hearty cooperation of everybody in the scheme. The work can not be successful without the enthusiastic support of the administration and of the local officers. In the inauguration of a plan of this nature the following points are sure to present themselves:

1. The selection of a shop instructor already employed in some capacity at the shop in question, who is preferably an up-to-date all-around machinist competent to give direct instruction in the machinist trade, but with sufficient knowledge of the other trades which may have local apprentices to be able to intelligently supervise apprentices in those trades.

2. The selection of drawing instructors, preferably draftsmen or mechanical engineers, who possess the rare qualities necessary to successfully instruct ungraded classes under new and trying conditions.

3. To obtain and equip suitable class-rooms located near the center of the shop property.

4. To secure the hearty coöperation of shop superintendent, foremen, gang bosses and mechanics who have been trained under a different system, and whose coöperation is essential to make such an apprentice system a success.

5. To obtain from the average apprentice a proper appreciation of the opportunities offered and an enthusiastic endeavor to make the most of them.

6. To introduce the training system for apprentices in a manner that will not interfere with the operation of the shops.

Present Operation—Extent.—The plan is now in operation at nine of the largest shops of the system, and includes about 450 apprentices. The work is gradually being extended to the smaller shops. The drawing instructor in every instance is a draftsman or mechanical engineer, located either at the shop or a company drafting room close at hand. The shop instructor in most instances holds some other position in the shop in addition to that of apprentice instructor. The apprentices are under the foreman, and responsible to him as formerly, but the foreman is relieved of the duty of instructing them in the trade, thus enabling him to give his entire time to directing the work of his department.

Methods.—The work in drawing and shop problems is outlined at the apprentice headquarters at New York City, and sufficient flexibility is allowed to fit the personality of the local instructor and the needs of the local apprentices. The plan of instruction is arranged to give the closest possible connection between the work in the shop and the work in the classroom. In fact, the practical and theoretical parts of the work are so thoroughly united that the grease of the shop is literally rubbed into the lesson sheets and drawing papers. Subjects are not classified as in most school systems, but the necessary mathematics, mechanics, physics and chemistry are introduced only as needed to solve some practical shop problem. The drawing is from actual parts from the start, omitting all exercises and preliminary geometrical work as such, and introducing principles only as needed to gain practical ends. Simple blue-print sketches are used for the drawings in connection with the actual machine parts; printed sheets are supplied for the problems. The shop instructors coöperate with the drawing instructors in looking after the general welfare of the boys. Arrangements are made for the instructors to make occasional visits to other shops to observe methods of instruction. Apprentices are sent to visit other shops and report their observations.

Class Work.—The instruction is largely individual, with classes limited to twenty-four apprentices at one time. By use of the blue-print sketches, on which are the necessary directions, it is possible for the instructor to hand an apprentice a sketch and a machine part, thus enabling the apprentice to start at once on the work. This method permits the instructor to keep a class of twenty-four busy, even when each member is working on a different sheet. The first drawings are very simple, so that accuracy may be insisted upon from the start. In order to save time and have corrections made at once, no work is removed from the drawing board until it receives the instructor's O. K. The work is scaled so that it can not be copied from the sketch and the course is arranged to advance more slowly than usual drawing courses. One principle is introduced at a time, and then only as needed to make an actual car or locomotive drawing. Lettering is an incidental item. The shop problems are usually worked at home on standard sheets, and an occasional blackboard review is given in class. The home work is assigned on loose printed sheets which makes it possible for an apprentice to go as rapidly as he desires. In the courses that are now used, much that is dear to the mathematician and physicist has been left out. All the work that is introduced is in accordance with the New York Central Lines practice, from which illustrations are selected. A comprehensive system of reports is made by both instructors to the local shop officers. These reports show: First, the ability at the trade; second, the disposition and personality of the apprentice, and, third, the standing in class work. The instructors are at all times required to know the standing of each apprentice, thus making examinations unnecessary. Special emphasis is placed on the personal touch maintained between the instructor and the apprentice, with a view to determining the type of work or branch of service for which the boy is best fitted. It has been found necessary to use great care in selecting instructors, who must be men who are not only competent, but who are willing to undertake the work for the love of it and their interest in the young men, as well as for the remuneration they receive. At the expiration of apprenticeship, those who have satisfactorily completed their term receive certificates which entitle them to preference in employment at all shops on the New York Central Lines.

Hours.—Instruction is given each apprentice four hours a week during shop time; that is, two mornings from 7 to 9 o'clock. Such instruction is all classed under the name of mechanical drawing. Apprentices ring in before coming to class and are under shop discipline during the session. At 9 o'clock they proceed directly to the shop. Home work is expected on the problems. Both instructors are available for consultation during the noon hour.

Facilities.—The facilities for handling work of this nature on a railroad are almost boundless. The authors appreciate the fact that they have only made a beginning thus far and that the apparatus at hand in most railroad shops would rival the outfits of some of the laboratories in the large technical schools. It is possible to have occasional demonstrations in the company's testing laboratories and to conduct steam consumption tests on locomotives and power plants. Home-made apparatus can be readily constructed or old machines altered to make satisfactory demonstrations of the most useful and fundamental laws of nature, and, better still, the practical applications of these principles can be shown in machines and other appliances on the shop property. The concentration of motive power responsibilities of a number of roads under a single general officer renders it possible to inaugurate a much more comprehensive plan than a single road or a number of small roads could attempt.

Attitude of Men.—The rank and file, not excepting the politician, the labor reformer, the practical joker and the workmen of all grades and peculiarities, unite in giving their approval to a plan, the object of which is to train their own sons in a business that will enable them to gain a livelihood and possibly advance to a position of authority and responsibility.

Interest of Apprentices.—No more interesting study has presented itself than the personality of the average apprentice. On the whole he is below the standard of education and ambition generally presumed by most motive power officers, who naturally think all apprentices possess the same exceptional initiative and earnest endeavor which has brought them up from the ranks. The average apprentice possesses a great deal of human nature; he means well, intends to make the most of his opportunity, generally prefers to be a real boy and to enjoy life, rather than to work problems at home; he will not read a text-book except under compulsion, and has absorbed a little of the idea that the easiest way to become a journeyman is to do as little work as possible. On the whole, however, the interest of the apprentice is good, and is increasing in proportion as the facilities for experimental work are increased and the plan of instruction is extended. There are instances where the boys have kept the local instructors busy in supplying them with work, and it is evident that the ambition of many boys has been aroused and

that the right chord has been struck, so that in time the boy without ambition will become a rare article. Reports show that apprentices started during the last year have evidenced a most commendable enthusiasm. On January 1, 1907, there were no less than forty-five letters of commendation from the superintendent of apprentices. It might also be interesting to state that at nearly all points there are advanced apprentices who take full charge of classes when the instructors are absent.

Effect on Apprentices.—The effect upon the apprentices has been awakened interest and marked improvement in skill in the shop, ability to read drawings, ability to lay out templates, and in several cases skill in drafting sufficient to warrant assignment to the drafting room for sixty-day intervals.

Effect Upon Output.—It is difficult to determine exactly the effect upon output. The time spent in class, four hours per week, would appear to cause a slight decrease, but this is more than offset by the increased skill of the apprentices, due to the presence of the shop instructor, to make each machine count, even with a green apprentice. It should be understood that all of the work done by the apprentices is on the regular shop machines and forms a part of the shop output.

Effect Upon Men.—A feeling among the men that perhaps the apprentices would outdo them has been met by the organization of evening classes for foremen and mechanics at seven shops, taught by the drawing instructors of the apprentice department. The finances of these classes are handled by the instructors, while the company provides the use of the room, light and heat, and gives the men the benefit of the courses provided for the apprentices, with the slight changes necessary to suit the conditions of the evening classes. The men provide all their own materials and drawing instruments. The classes meet once or twice a week for two-hour periods, either directly after working hours or in the evening. While the total enrollment was but 150 this year, it nevertheless expresses the general feeling among the leading men in each shop. The result has been a closer intimacy on the part of the shop men with the shop draftsmen and with company standards.

Effect Upon Instructors.—The effect upon the instructors themselves has been most pleasing. Without exception, they have developed, not only as enthusiastic instructors, but also in all-around ability. The exigencies of teaching have brought them in contact with many features of the service previously overlooked and the occasional observation trips and interchange of ideas have already made them more valuable to the service. Many valuable suggestions have been received from the instructors and adopted.

Treatment of Apprentices after Graduation.—Perhaps as vital as any other principle is the necessity for caring for graduates with infinite pains after they have completed their apprentice terms. The results of the best possible apprentice system may be absolutely nullified if the organization into which the graduates are to go is not properly prepared to receive them. It is not too much to say that most railroads and most large industrial establishments need to put their organization in such order as will render not only employment desirable, but advancement possible. As an incentive to all and a reward to the especially studious and proficient, it is desirable to give a limited number of those showing the best records a prize in the way of a more advanced course at a technical school at the expense of the railroad; the young man to work in the shops during vacation time, thus retaining his close relationship to the work.

Probable Results.—It will undoubtedly take years to show the full value of the apprentice system. Already draftsmen are being provided for the company drafting rooms, and New York Central standards are becoming familiar to all apprentices. In the future every journeyman will be able to read drawings and make working sketches. Men will show greater pride in their local shop and increased loyalty to the company, and the tendency to resign their positions for work with other companies will be lessened. It is not expected that all of the boys will attain a degree of efficiency that will qualify them for leadership, or that all workmen will possess the same measure of ability and activity, on account of the difference in their natural intellectual and physical qualifications, but it is expected that each will be developed to a high degree in his particular line, with the result that eventually each shop will be manned by a force of mechanics embodying an advanced state of proficiency from which at least a few competent men may be had at all times for positions of leadership.

Attitude of Other Roads.—The criticism has been made that the New York Central Lines is educating apprentices for other roads, and the statement is to some extent true at present. The awakening of interest, however, in industrial education, and the inquiries and observations from all directions, indicate that other railroads are now giving this matter the consideration it deserves, and in some instances have taken action with a view to inaugurating some part of the plan proposed. The fact is being appreciated that no outside system of instruction, such as trade schools, correspondence schools, or even Y. M. C. A., can fully meet the needs of the apprentice, and that the control and direction of the instruction must be coincident with the control and direction of the shop. The indications point to a day not far distant when each railroad will have a fully equipped apprentice system organized as an integral part of its motive power department. Before such work can start, the management must be convinced that for its own safety in the future it must be provided with skilled, intelligent native workmen; men who can stand on their own merits and do the work which is needed to keep this country commercially ahead of the world; men who need hide behind no organization to command the respect of their employers; men who can and will bring skill and judgment to their work so that they may command compensation commensurate with their increased ability.

Abstract of Discussion.

Mr. A. M. Waitt.—It seems to me that at the present time there is no more serious problem confronting the railroads, and especially the mechanical department of railroads, than the future relationship between the employes in the mechanical department and the companies. We find that probably as much of the time of motive-power officers is taken up in considering the difficulties of the labor problem as is devoted to strictly technical subjects. The growing tendency to specialization seems to have led to a lack of general all around mechanics, and it has been noticed in probably every shop in the country that there is a great dearth of suitable men when a good man is desired for the position of foreman. The problem has got to be faced, and it seems to me that the step taken by the New York Central Lines, on a comprehensive and broad scale, is one of the most important ones that has been taken by railroads in this country for a long time. Especially it seems to me fortunate that the New York Central people should be willing to make public, even in the early days of their apprenticeship system, what they are doing, what they are contemplating, and the methods by which they expect to produce greater results in the future than they have in the one year in which the system has been in operation. I was very much interested since coming here to see that as a supplement to the paper prepared by Mr. Cross, the American Engineer and Railroad Journal had published a lengthy article, which it would appear is going to be one of many, outlining in detail the system that has been inaugurated on the New York Central Lines. I read it somewhat hastily, but with a great deal of interest, and I believe it can be read with profit by every gentleman who is present at the convention, for I think there is nothing more important for the future good of railroads, for raising the standard of mechanics in the shops, than the establishment of a thoroughly comprehensive and wisely carried out system for educating apprentices, so that we can have good all-around mechanics.

There has been a tendency lately, in connection with various organizations, to lower seemingly the standard of efficiency of the men. I believe that a system such as has been outlined by Mr. Cross is one of the steps to offset that tendency and to raise the standard permanently, so that instead of going through our shops and comparing the present class of men with those of fifteen or twenty years ago, and commenting as we do now that they are not up to the old standard, that we may in five or ten years from now look through the shops and find the standard constantly improving, and so that the railroads may be looked to as an example of the best methods of raising the calibre and the general standard of the mechanics.

There is a common tendency in shops for general foremen to feel that they must, in taking young fellows into the shop and training them eventually to become mechanics, get all that they can out of them, forgetting that one of the desirable features in training apprentices is to make them first-class workmen. The value cannot come in the first years of their apprenticeship, but just as surely as they are properly trained the value will come

to the company and to the community at large after they have been properly trained.

Mr. J. A. Pilcher (Mechanical Engineer).—In connection with the apprenticeship question, the Norfolk & Western has a system of allowing the apprentice a certain amount of time in the draughting room. That has been carried on for several years, with the result that our most efficient draughtsmen are men we have secured from the shops originally as apprentices. In several instances where men did not develop just the talent we would have liked for the draughting room they have gone back to the shops, and later on I would find they were made gang foremen.

Mr. Harrington Emerson.—I think all those who have had to do with labor in railroad shops have felt very much the need of providing some method of training to develop the future workers in the shops, and therefore will welcome this magnificent work that has been going on in that line on the New York Central Railroad. On the Santa Fé I have felt that need because we had there nothing that could be called an apprenticeship system. We had the old method of taking in apprentices, of getting what we could out of them, and getting what assistance we could through certain classes of the Y. M. C. A.

We have, however, been fortunate in being able to check up the work of the apprentices, the work they were actually doing against what they ought to do, and I think it might be of interest to give this meeting a statement of what apprentices under the old system were doing—which I hope will soon become obsolete—and perhaps sometime in the future it may be possible to find out what they are doing under these new systems that I hope to see spread. In the boiler shop we had 23 apprentices whose average efficiency was 87 per cent. in the work that they did. The efficiency of the whole shop, including the apprentices, was 94 per cent., so that the apprentices as a rule were below the efficiency of the men. On the list I found one apprentice with an efficiency of 136 per cent., and another with an efficiency of only 43 per cent. Coming to the machine shop there are 56 apprentices with an average efficiency of only 69 per cent. The first man on the list has an efficiency of 136.8 per cent., the next man an efficiency of only 33 per cent., showing the tremendous variation in individuals. The first man is four times as good as the second man, and my impression is that throughout life he will steadily gain, as time goes on, and he will not be only four times as good, but ultimately ten or twenty or one hundred times as good, and one of the features that perhaps is necessary, is to check up the apprentices throughout their course of service with reference to their efficiency, so as to encourage those who show a high degree of efficiency, and if possible divert those that show no ability whatever into possibly other walks in life. During the time of apprenticeship, more than at any other period of life, it seems to be necessary to impress upon the apprentice the question of his own efficiency, that what he is learning is not simply to absorb a certain amount of knowledge, but to carry it into actual work so that he himself becomes efficient.

Mr. D. R. MacBain (Michigan Central).—While the system has been in force only a little over a year, the results so far are very gratifying and the conditions are bettering all the time. When we were trying to carry out our old system of apprenticeship, when we undertook to have the apprentices attend a course of instruction for an hour or an hour and a half after the work of the day, we found that we got little results—the boys did not put the enthusiasm into the work which they are doing now.

We find also since the inauguration of the new system, and particularly within the last five or six months, since the thing has become advertised to a considerable extent, that we are getting a much better class of young men than before. They have learned and understand now that our apprenticeship system is very much like a fairly good technical education. For that reason there are many more applications than we can take care of.

I believe a more liberal treatment of the boys after they have finished their apprenticeship will be necessary. We have in the last two or three years broken away from the old practice of increasing the boys 25 cents a year after the apprenticeship, and instead of that have been governed by the recommendations of the machine foremen, general foremen and others. The result of that is we are saving to the Michigan Central Railroad men whom we believe in most instances are superior to the first-class journeyman who may apply for a position.

Within the last three months two of our apprentices who took up this work when the system was inaugurated a year ago have been called into the mechanical engineer's office. One is in Mr. Gilbert's office in New York and doing well. Another man was called into Mr. McRae's office in Detroit. Such instances as these are the very best recommendations which can be made for the system. We no longer have the trouble we used to have to get the boys to stay and work through the period of apprenticeship.

Prof. H. Wade Hibbard (Cornell University).—We find in an engineering college that a very great deal of good comes to us from the opportunity we have in a faculty, of say fifty engineering professors and instructors, of discussing things together. It strikes me as the New York Central has its meetings of motive power officials at various periods, that the superintendents of the apprenticeship instruction courses might as often or oftener hold meetings of men engaged in this work of instruction, that they may come together and talk over the subjects, some of which could be outlined beforehand, and some of which could be brought up on the spur of the moment, that are necessary for the continued progress and the excellence of their work. It will be necessary that the students in the apprenticeship course should be aided in every way so that the enthusiasm in the courses may be kept up. A new thing is attractive, but when the novelty is worn off, the attractiveness diminishes and the enthusiasm begins to wane. It strikes me that special effort should be concentrated upon this, as in other matters of the course, to keep up the enthusiasm all through the line—enthusiasm of instructors and the enthusiasm of the apprentice boys.

Now with regard to the instructors, I wish to make a suggestion, and that is the danger which may come from the men who are doing the instructing in the different shops, leaving the service of the company, being promoted, having duties placed upon them inconsistent with the carrying out of the duties they are now carrying out in the apprenticeship instruction work, etc. Of course, in our university work we have professors who leave the college, but there is so concentrated an interest by having a large number of instructors in one faculty, that the purpose of instructive work as a continuity, even though one or two professors occasionally leave is not broken.

Mr. G. M. Basford.—Nearly all railroads and industrial establishments have preached apprenticeship and nearly all have made serious efforts to practice it. In spite of this it would probably require from 40 to 70 years for most of these establishments to recruit their service of skilled labor through apprenticeship if they relied upon present methods for the purpose. The past generation and the present have brought a tremendous growth to all our organizations, the extent of which none of us, probably, fully realizes. We have greater need than ever for trained young men ready to be trusted with responsibilities.

For many years the technical schools have done their best to supply men for leading positions, and yet we are suffering for men to fill subordinate positions. Well-prepared men from the ranks are what we want. This plan so clearly described by the author of this paper will undoubtedly produce them. We need definite, systematic apprenticeship, adapted to present conditions. Even if we had plenty of apprentice material, shop people are too busy to teach boys, and if the boys are put into the shop organization to learn trades, under prevailing conditions they will quickly absorb much that is harmful and more slowly learn some of the things we wish them to know. Under present methods and conditions, they certainly cannot be said to learn trades. This plan insures the acquisition of a trade. It does more. It also insures mental development to correspond, and a certain moral training must necessarily result.

For sixty years the British navy has profited by a plan somewhat similar to this. It is, therefore, clear that this plan does not contemplate the tilling of new soil.

The State of New York, at the Elmira Reformatory, in 1894, provided instruction in 34 separate trades to those who were (shall we say) fortunate enough to have an opportunity to learn them. In 1879 a school of letters was established at the same institution as a part of an elaborate and effective educational scheme. If we had needed any precedent, here we had one years ago, and it will be to our everlasting disgrace if we permit it to be truly said that a young man, in order to learn a trade needs to commit a crime against the laws of the people.

The New York Central has shown the way to solve the recruiting problem practically. Let us hope that all other roads and manufacturers will follow as rapidly as possible.

Mr. E. Chamberlain (N. Y. C.)—Most of us have served our time at a trade, and many have been apprentices, and we know the difficulties we have had to overcome in becoming masters of our trade. If you were to see upon the New York Central Lines as a whole, the eagerness, the ambition of these young men to better their conditions through the privileges afforded, at the expense of the company, it would be a marvel to you indeed.

Mr. William McIntosh (C. of N. J.)—In former methods of apprentice instruction the effort has always been made to give the boy instruction outside of the regular working hours, expecting them to go back to the works after the regular hours of the day and to give considerable time at night to instruction. It is not surprising that it did not prove successful, for the reason that very few of us who have passed the apprenticeship period would be willing to put in additional hours in that manner if we could avoid it. Therefore, the plan adopted to give instruction during regular working hours is one of the important features of the system, and one that is absolutely necessary to meet with success.

The road with which I am connected was interested in improving the apprenticeship system by methods of instruction some time ago, and in 1905 we established a school in connection with our road very much along the lines of the New York Central. I want to give due credit to Mr. Basford for the effort that he put forth to induce railroad people to take up these methods of instruction. It was largely due to his suggestions in this connection that our people were induced to adopt the plan. I believe we have sixty scholars under instruction at the present

time, and some of them advancing very rapidly, so much so that I do not think the New York Central need fear having to lose all the graduate apprentices, for we would be able, in proportion to the size of our road, probably to reciprocate to a modest extent. Our experience has been most satisfactory.

Mr. LeGrand Parish (L. S. & M. S.)—This method of instructing apprentices is a good, sound business proposition, no theory in it. We have found that by placing an instructor in the shops to instruct the boys we get a much greater output from them. We are not losing anything in the matter of dollars and cents, and, from the financial point of view, we are gaining. I have also found something which will be of interest to everybody concerned, and that is that in discussing this matter a short time ago with a committee of our machinists they expressed themselves as delighted with the system, and, in fact, gave me considerable concessions in connection with the number of apprentices, showing conclusively that the men themselves are in thorough sympathy with the plan.

Mr. L. R. Pomeroy.—It seems to me this plan has in itself the essence of success, because it is not philanthropic. I think the system has just this advantage, that we can make better journeymen out of the ordinary apprentice, with the possibility of now and then finding a good foreman. My mind has been going over the numerous schools which have been started along these lines, notably the work done by such men as Reynolds, at Brainerd; W. Slacks, at Denver; Linmark, at Chicago; Reed, of the Chicago & Great Western; Wilkinson, at Jackson; Bradley, at Ann Arbor, and Brooks, at Dunkirk. Notable work was performed at every one of these places, but the fundamental difficulty and the cause of failure was that they had no control over the men, it was all voluntary. Under this system, where the company pays them for the time that they are giving to instruction, the question of discipline is prominent, and it gives them a better control and direction over the men.

Mr. D. J. Redding (P. & L. E.)—I am connected with a shop having one of these schools. One of the difficulties mentioned in the paper is to obtain from the average apprentice a proper appreciation of the opportunities offered and an enthusiastic endeavor to make the most of them. I want to say we feel that this has been overcome from the fact that in some cases apprentices have asked permission to attend the night classes as well as their regular day courses, in order that they may advance more rapidly. I have one case of a man employed as a machinist working at full wages, who worked up to that position from laborer, who came in and wanted to enter the shop as an apprentice and was willing to serve two years in order to get the advantages of the course.

There is no question but that the average apprentice when he first comes in as a boy, 16 or 17 years old, is, as a general thing, not interested. He does not know whether he really wants to be a machinist, boilermaker, or blacksmith. We observe that their interest in the work develops more after they have been in the shop for some time, a year or two, and we also find that some of the mechanics who have developed themselves under this system are men who went into the shop as laborers and depended on their own resources to work at different callings, but found without some special training they would not advance very far. After they have worked in the shop a year or two they are given opportunity, if they desire, to give a portion of their time under the apprentice system, and these men usually make very good mechanics, because they realize they must learn a trade to get on, realizing this necessity more than the younger men do.

As to the matter of output, we do not find there is any trouble whatever. Four hours a week spent by the boy in the school is as a general thing made up by increased efficiency. It may not apply to the first year, when the boy is running a small lathe, or some small machine, but it does come in in the second or third year.

Apparently the system is having a good effect on the shop men, as we have had more interest in the night schools since this system has been started. We did not have so large an attendance before, and the foremen are attending these classes now more than ever.

The attitude of other roads is mentioned. I believe everybody agrees that you cannot make a much better investment than to spend a little money on educating the apprentices, no matter what the size of the road may be. A small road might not want to go to the expense the New York Central has undertaken, but practically the same system can be carried on with very little expense. Smaller roads can obtain the lesson papers from some outside source, and a very little attention on the part of the officials would give splendid results.

It occurred to me when I got a copy of this paper that it might be of interest to know what the boys thought about it. One thing is to prescribe a course of medicine for a man, and another, to know how it works. I wrote to the boys in the second and third year and asked them to say what they thought of the apprentice course, whether it was a benefit to them or not, and asked them not to sign their names to the papers, as I wanted them to say only what they wished to say, freely and frankly. Part of one of the letters, which is quite characteristic, is as follows:

"The drawing school is going to make a better machinist of me than I would have been without it, because I learned there lots of things concerning the work which I would never thought of myself. I know that I shall, when my term is up, feel more confident and more satisfied with myself than I would if I had not received the drawing school training."

Dr. W. F. M. Goss (Purdue University).—No more important matter awaits the attention of the management of American railways than that of training men for its service. For years past, large sums of money have been spent in the improvement of tracks, in perfecting equipments and in the elaboration of problems involved by the operation of trains. But the effectiveness of these improvements in material things, must, in the long run, depend upon the degree of intelligence which controls their use. If the training of men has kept pace with the increased complication and higher efficiency of the material equipment employed, there will be no lack, otherwise there will be a condition of unbalance, as of a refined instrument in hands insufficiently trained to guide it. It takes time to improve an organization. In the matter of training men, it is less a question of to-day's efficiency than it is a matter of to-day's preparation for results which must be forthcoming to-morrow. This fact gives increased significance to the apprenticeship system of the New York Central Lines. The benefit cannot be immediate—it looks to the future. The plan which has been adopted is, I think, admirable. By beginning with the apprentice boys, it starts right, and, by giving systematic attention to the intellectual development of the apprentices, it proceeds along correct lines. I have no hesitation in saying that the railroad company projecting this system will receive large returns upon its investment; and I must add that the adoption of such a system well reflects the broad and progressive spirit which so often characterizes the acts of our worthy president.

As one from the college, I cannot refrain from calling attention in this connection to a lack of interest on the part of American railways in men from the college. In making this statement, I freely admit that the time has passed when a college diploma could be accepted as evidence of ability. Not all college men are intellectual giants, but the fact remains that among the graduates of our colleges are men who have good physique and sound minds, men who are able and willing to work, whose purposes are strong and whose characters are fine. The manufacturing interests of our country recognize this fact. Each year, in March or April, representatives of many of these establishments visit the colleges in their search for men whom they can start at the bottom of their organizations. In the exercise of their choice they are painstaking and discriminating. These manufacturing industries are not more important to the welfare of our country than the great railway corporations. They probably have no greater need of young men of superior quality than have the railroads. Nevertheless, it is my observation that railway companies do not ordinarily show an equal interest in recruiting their staff.

Mr. W. B. Russell (N. Y. C. Lines).—It was predicted before we started this plan that the apprentice system would not last three months, and it probably would have failed, at least on the educational side, if the ordinary methods of instruction had been followed. The apprentice, as we find him, is not a man who can appreciate college methods, or any adaptation of college methods to his case. High school training will not fit him. It has been necessary to start fresh from the beginning and develop a system of training to fit the special need we have here in America.

The two features of the work are the drawing courses and what are called the problem courses. Drawing courses for apprentices are nothing new, but our method of teaching drawing is different from anything I know of in this country. The geometrical work, which ordinarily takes a year or two in most evening schools, is omitted entirely. The boy starts immediately on practical work, being called upon to deal with actual conditions. The geometrical knowledge may be necessary, but is introduced as it is wanted. We do not teach him the principle and then let him apply it, but teach the application and the principle at the same time, the idea being to keep in view at all times the practical result to be gained. In our public school systems we have overlooked many important points. This work must go much slower than ordinary school courses.

The apprentice does not appreciate a lecture; it is wasted. The work must be individual, no system of teaching which requires the same standard from each apprentice will fill the bill. The standard must be an individual one; the quantity of ground to be covered is not an element in this. All of our public schools and high schools are intended to train for college, the high schools especially teach with that end in view, and our public school training is drifting into that line. In the case of the work we are doing we have no college requirements to meet. What we are trying to make in this instance are men, and the best method does not consist in the quantity of work they cover, but how they cover it.

With the apprentice no class work can be undertaken because the classes, which are limited to 24, may contain a boy just starting as an apprentice and another about to finish. By means of

blue print sketches it is possible for one instructor to keep each boy in the class on a different problem. These sketches give the apprentice full instructions as to what he is to do and how he is to do it, saving the instructor from the necessity of repeating details to each boy. The instructor is present to oversee the work. If the work was being carried out in a single shop, where the mechanical engineers and officers could father it and watch over it, many things could be done which it is impossible to do with schools widely scattered. Our schools are so located that it is impossible in some instances to visit them oftener than once a month. Nevertheless under these conditions the educational features work out successfully.

The second part of the work, the problem course, is unique in this respect, that we have nothing to fall back upon. As a matter of fact we have had to leave out everything in the text-books and have found it impossible to use them. There is nothing in this country at the present time to fit the needs of the apprentice, and it has been necessary to start from the beginning. The practical problem is first stated and solved, then followed by a sufficient number of similar problems to cause the principle to take root. In every-day life we do not have a classification of arithmetic, geometry, etc., but the problems are a combination of these subjects. It would be impossible, however, to take problems directly from the shop as they come up and give them to the apprentices, but it is possible to select problems that will slowly increase in difficulty and thus use actual shop problems in instructing apprentices. In doing this there is no subdivision into arithmetic and algebra. If the problem requires algebra for its solution the necessary amount will be introduced, but without the apprentice knowing it. At one of the points the boys found that they were working problems similar to those in the fourth year of the high school course and the result of the discovery was that they became frightened and did not do the work so well.

Our aim in connection with these problems is to make them fit in as closely as possible with the boys' daily work. We get the problems from the instructors and mechanics, and pick them up wherever we can, using all the illustrations possible from actual road conditions, taking the data of a problem from the local division of a road, if possible.

I want to emphasize the matter of the personal touch between the apprentices and the instructor, and between the instructors and the heads of the apprentice department. This statement may sound queer from an educational standpoint, but it has been clearly demonstrated that the personality of an instructor counts for much more than his actual knowledge. The personal touch is the key to the situation. If the instructor does not know his pupil well enough so that the pupil will interrupt him in order to ask a question—if the relations between the instructor and the apprentices are not on such a footing that they feel at liberty to do this—he is not a good instructor. In many cases instructors are called by their first names by the apprentices, which shows how closely they work together. Many of our best instructors find it necessary to study at night in order to keep ahead of their classes. They make the best instructors because they can look at a subject from the apprentice's standpoint, and can bring the apprentice up step by step, appreciating all of the difficulties because of the fact that they are studying themselves.

Referring to Prof. Hibbard's remarks. The state cannot undertake the whole of this educational work. It is true that our public school system is not preparing the right kind of men for apprentices. It is more and more evident that even high school graduates who come to us are deficient in many respects. In public school work it would be impossible to pick illustrations to suit in a single class all of the trades which the school should fit for. This is noticeable in evening classes, where the same class may contain a marine engineer, a locomotive engineer, a stationary engineer, a hardware clerk, and possibly a clerk from a drygoods store.

In regard to the college faculty, and the advantages to be attained there, we have somewhat similar conditions in the fact of instructors visiting other schools, and it is arranged that at least once a year they will come together at one point. Shop visits are arranged for, and occasionally three or four instructors meet at one place to compare notes. The rivalry between the schools is very apparent and results in much good.

In regard to an understudy. We have now at most shops a man ready to step in and take the instructor's place. Since starting we have had at two schools three different instructors and yet the work has gone on smoothly. What at first promised to be our greatest difficulty—the securing of instructors—has proved to be an easy matter. We have no dearth of instructors, are rapidly educating our own and already have a number of men at various shops who are thoroughly qualified. In this connection the mechanical engineer's department is cooperating by selecting only such men for shop draftsmen as will be capable in time of making good instructors. At each point on the system there is at least one apprentice who can take full charge of the class for one or two weeks and in one instance a shop instructor carried the entire educational work for a month while the regular instructor was ill. This was possible because of the arrangement of the work

We are endeavoring, as rapidly as possible, to bring in experimental work, not the kind the colleges have, because we are not trying to prove the laws of nature, but the kind that will demonstrate and show the reason for things. We have introduced at most points a small engine, because we have found many apprentices did not know what a valve was, nor understand the definition of lap and lead. It is not too much to predict that every machinist apprentice will be able to set valves before he graduates.

It was stated that this plan would not work where piecework was inaugurated. It will work equally well with either piecework or day work. We have it on both plans. Specialization and not piecework is to blame for the present lack of apprentices. This plan will also work in a small shop and we expect to put it in shops where there are only five apprentices. It may be in this case that the shop instructor and the educational instructor will be one and the same man, and will give only a small portion of his time to the apprentice work.

Provision is made in the apprenticeship regulations for allowance to be made for previous experience, and that covers the college man. We have no objection to his taking our regular apprenticeship course. Allowance in time and rate of pay can be made with the assent of the superintendent of apprentices, so that it is an individual matter.

The system was started so gradually that the question of enthusiasm was not a factor. There is more enthusiasm now than there was a year ago. We had a letter the other day from one school saying that there were 12 boys who were out of problems and it was up to us to supply them—that shows the enthusiasm. The statement was made that we were supplying leaders rather than mechanics. If Mr. Setchell could see some of our apprentices, for example, in the foundry and boiler shop, he would realize that some of them, at least, would never become leaders. *It is not our intention to educate apprentices out of the trade but in the trade.* We aim to reach the rank and file—the geniuses will take advantage of the conditions created and take care of themselves. The educational courses are not designed for high school graduates, but for the average apprentice, as we find him, frequently a young man who cannot tell how many sixteenths there are in an inch, but who may develop into a good workman in the shop. It is true that we are supplying draftsmen for some parts of our road, but this is a part of our plan, as when we find a man adapted for the drafting room it is to his interest and the company's interest to place him there.

Prof. H. Wade Hibbard.—In the absence of any one from the Pennsylvania Railroad being in the room just at the moment, I beg to read a half page from a recent number of the *Engineering Magazine*, in connection with an article entitled "A Railroad University. Altoona and Its Methods." "During the latter days of February, 1907, the city of Altoona added to its educational facilities a railroad high school, which is the first institution of its kind in the United States. Its progress may mark the beginning of a new era in education, if other industrial corporations see the advantages of forming such a working partnership with the public schools as the Pennsylvania Railroad has made in Altoona The industrial department of this high school is fully equipped and all bills are paid by the railroad company. The department has nothing in common with manual training. A four years' course is planned, beginning with mechanical drawing and ending with machine design. The creation of the department is the result of a desire on the part of the railroad to discover a way to combine its needs for trained employees with the aim of the public school authorities to turn out young men ready to earn a living."

"A drawing room, carpenter shop, forging room, a wood and metal working machinery department—all equipped with modern tools—together with the expert instruction to be provided, will enable the school to give students advantages heretofore enjoyed only by pupils of the best technical colleges."

"Graduates of the Altoona high school will be fitted to go directly into the Pennsylvania shops on a footing between the regular apprentices who, as a rule, entirely lack training, and the more mature apprentices who are graduates of technical colleges. The railroad's return on its investment is expected in the way of better educated employees."

I would like to say in closing that I said yesterday no word with regard to the place of the graduate of the technical college. Some one met me after the meeting and said: "Why didn't you jump on this scheme; the New York Central is not going to take any more of your boys who graduate from your engineering college onto its lines." I said to my questioner, "You are entirely mistaken." I have talked with these people about this matter, and as an illustration told him that one of my boys who will graduate next week, who applied to Mr. Cross and told him he was going to graduate, and that he had also had some practical experience working in railroad shops in the summer time, and they said to him, "We will allow you two years for your educational experience, and summer vacation shop experience and ask you to serve two more years in this apprenticeship course." That is fine—what I believe in exactly, and what most of you gentlemen believe in.

I am getting tired of the words "special apprentice." I am getting tired of having a college man think he is going to be mollycoddled after he gets out of college. We do not want to mollycoddle him in college, and certainly you do not want to mollycoddle him after he gets out of college. I would like to see the graduate of the engineering college take a regular apprenticeship course, learn the trade, and having that foundation he can take care of himself and show whether he is useful to his employers for promotion later on.

Mr. J. F. DeVoy (C. M. & St. P.).—I desire to speak of the system which was inaugurated some six years ago by the present superintendent of motive power, Mr. Manchester. There had not been up to that time any particular line of work mapped out for apprentices, and we were called together to formulate a plan. Some parts I wish to speak of, particularly that relating to the teaching of drawing. You are doubtless aware that in the western country there are a good many isolated roundhouses in which perhaps it might be difficult for the New York Central system or that advocated by them to be worked out with a great deal of satisfaction. Therefore it was decided that the last three months, or at any time at which it could be done, the apprentices should be sent to the Milwaukee shops, the principal shops of the road, to serve two months in the drawing room.

Mr. F. P. Roesch (Southern).—I would like to say that there has been inaugurated in the Spencer shops of the Southern Railway during the past few months, a system which, while it is modified somewhat, is practically on the same lines as laid down by Mr. Cross. We had some difficulty in getting the boys to take advantage of it, or inducing them to come into the school room. The principal trouble we found was due to the fact that most of the apprentices possessed only the rudiments of an elementary common school education, and for this reason did not realize the benefit that they would obtain from a higher education, or from taking advantage of the opportunities offered; but I am glad to say that we have overcome that to quite an extent. The boys are instructed during the working hours, come into the class room in their overalls, and, as Mr. Cross has stated in his paper, their thumb-marks are found on their lessons. They are taught all the elementary branches, as well as the higher branches. We find that with some of the boys it is necessary to commence at the beginning, to teach them the A, B, C's. From that on they are taught drawing, arithmetic, some of the elements of geometry, although not in a regular way; they are taught the strength of materials, what is the minimum cutting speed of the different steels and tools. The maximum cutting speeds we allow them to determine for themselves, and we find they are doing pretty well at that. We found that the best way to arouse enthusiasm in those who did not care to take advantage of this schooling was to allow those who were more advanced to make the shop drawings or shop sketches, signing their own names to these sketches. These sketches are of course checked by the instructors. When a few of these sketches are brought among the workmen and among the other boys, they question: "Did Billy Dunn make this sketch? Where did he learn it?" "Over in the school room." So now, not only the apprentices, but some of the mechanics and some of the helpers, have asked for the privilege of instruction, the blacksmiths and the car men are coming in.

C. A. Seley (C. R. I. & P.)—This system, as outlined in the paper, has appealed to me especially in regard to its directness of method. That which is taught in the colleges and schools is necessary for the rounding out of the education perhaps in various ways, but what this thing is for is to educate the rank and file. You cannot keep down the boy who has it in him to be a future master mechanic. You cannot make master mechanics by education. The issue has been raised, perhaps not on the floor, but in the minds of a good many, between the education of the technical schools and colleges and of the shop system. Unfortunately, I did not have the opportunity of a technical education, and I cannot speak from that side of it as well as I could otherwise, but I know from my own experience in handling men that each has to be considered as an individual, and he that has it in him cannot be kept down. The rank and file of mechanics in our shops, as every motive power officer knows, have deteriorated, and this is the best method that I have seen of raising the standard, and it will provide, as the paper has said, for some foremen, and perhaps some superintendents of motive power.

Mr. C. W. Cross.—In answer to Prof. Hibbard, I will say that our efforts are directed to the moderate advancement of a large number of young men, instead of the high advancement of a few. As has been mentioned, the genius will take care of himself in the race for advancement, as he always has done. There is no conflict between the training of the practical young man and the man from the college, but rather a co-relation between them. These young men are given a time allowance on their course for previous experience in school shops, and are considered perfectly able to take care of themselves in competition with others who have not has as good educational advantages as they have enjoyed.

Mr. Pratt mentioned the preference of the majority of young men for certain trades and the difficulty in obtaining desirable young men in other trades. This has been overcome to some extent by paying a higher rate of pay in some of the trades.

In reply to Mr. DeVoy, I would state that it is our practice to have apprentices transferred from one shop to another, also from one drawing room to another, to give them a more general experience and to develop initiative. We all know that when a boy serves his time at one shop and stays there after completing his time, he is looked upon as a boy, no matter how old he is, but if he goes to another shop he becomes a man immediately.

THE EFFICIENCY OF THE WORKER AND HIS RATE OF PAY.

To THE EDITOR: In an article of descriptive and analytical criticism of the highest order, in your June issue, Mr. Clive Hastings has lucidly set forth the different modern methods of paying labor—day rate, piece rates and bonus on day rates. It was natural that having found the weak points of day rates, of piece work payments and of bonus rewards he should have felt inspired to evolve a method free from defects in the existing plans.

His major premises are:

Firstly, that an automatic adjustment of rates without interference by the management is desirable.

Secondly, that the wage fund shall remain constant however the shop efficiency may vary.

Thirdly, that the wage fund shall be automatically distributed to workers in proportion, not to their absolute, but to their relative efficiencies to each other.

As to the first premise, what is needed is a closer and constant study of varying conditions by the management, not additional excuses for shirking this essential duty. What would we think of a woman who, possessing a beautiful head of hair, did it up most carefully once for all and then varnished it so as not to need to bother about it for a month? However carefully she may adjust her hair to-day, a neat woman will comb it and brush it twice a day, so that each individual filament may be without fail straightened out with respect both to itself and its surroundings. Each individual in a shop requires at least as much attention as a hair and it rather seems as if Mr. Hastings proposed to dispense with combs and brushes and use varnish.

The second premise, that the wage fund shall remain constant however the shop efficiency may vary is in fact the contention of many labor organizations, with the direct result of grading down in efficiency instead of up. If shop efficiency increases the owner can afford to pay increased wages and, as experience has proved, will gladly do it. If shop efficiency goes down it is so tremendously expensive that the owner must remedy conditions. While Mr. Hastings does not propose to do away with a record of different men's efficiencies and of shop efficiency as a whole, he does propose to free the owner from any obligation to pay for higher efficiency even if brought about by extraordinary individual or collective effort.

Thirdly, even in piece work and in that form of bonus which gives no bonus unless a certain minimum speed is attained, the workers combine to condemn the extra fast worker and the pressure is so great that he drops down to a permitted maximum. Mr. Hastings proposes that the man who does more than the average number of pieces shall be paid for the extra number, not by the shop owner who benefits, but by paying less to the man who does not reach standard. I fear the plan would be unpopular and that each man would get busy seeing how little he could do instead of how much.

HARRINGTON EMERSON.

LOCOMOTIVES SHOULD SUIT CONDITIONS.—In some instances trouble has been experienced with modern heavy locomotives, because of the continued use of methods and designs suitable only to the light power formerly employed. With the continued use of heavy engines, however, these faults are now being avoided. Cases may also be cited where engine failures have been frequent owing to the use of light locomotives which formerly did efficient work, but are unable to meet conditions as they exist to-day. Such failures have been rectified by the introduction of modern power.—*William Penn Evans before the Pacific Coast Railway Club.*

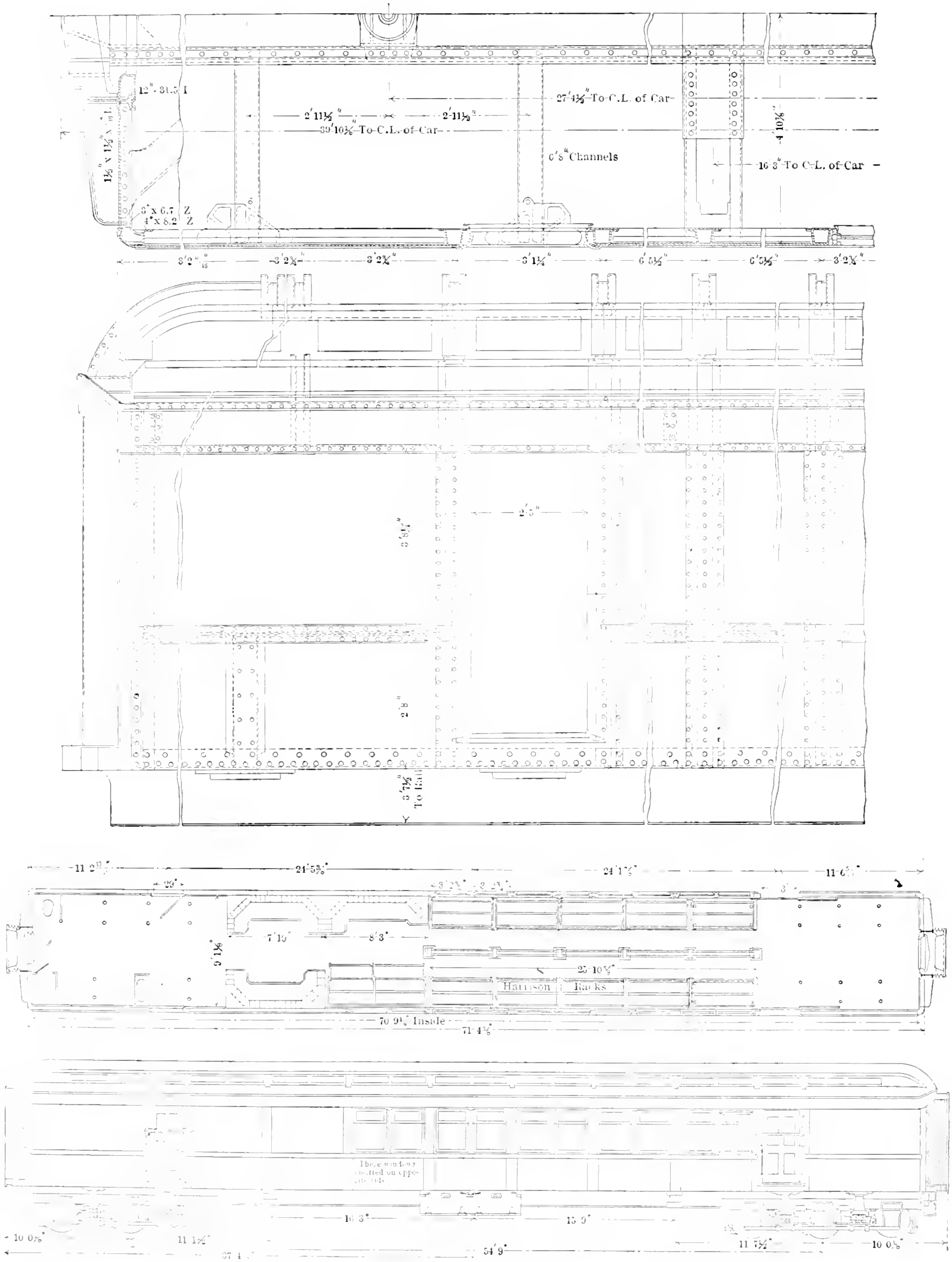
ALL STEEL PASSENGER SERVICE CARS.

PENNSYLVANIA RAILROAD.

POSTAL CAR.

These cars, which follow very closely the general principles used in the passenger coach, were briefly described and illustrated on page 136 of the April issue of this journal. At that time, however, drawings were not available and the description of the general structure will be repeated. Reference should be made to the previous article for views of the exterior and interior of the car and of its framing.

These cars are 70 ft. long, inside measurement, or 10 ft. longer than the present standard postal car. This extra length is used



PLAN AND ELEVATION OF 70-FOOT ALL-STEEL POSTAL CAR—PENNSYLVANIA RAILROAD.

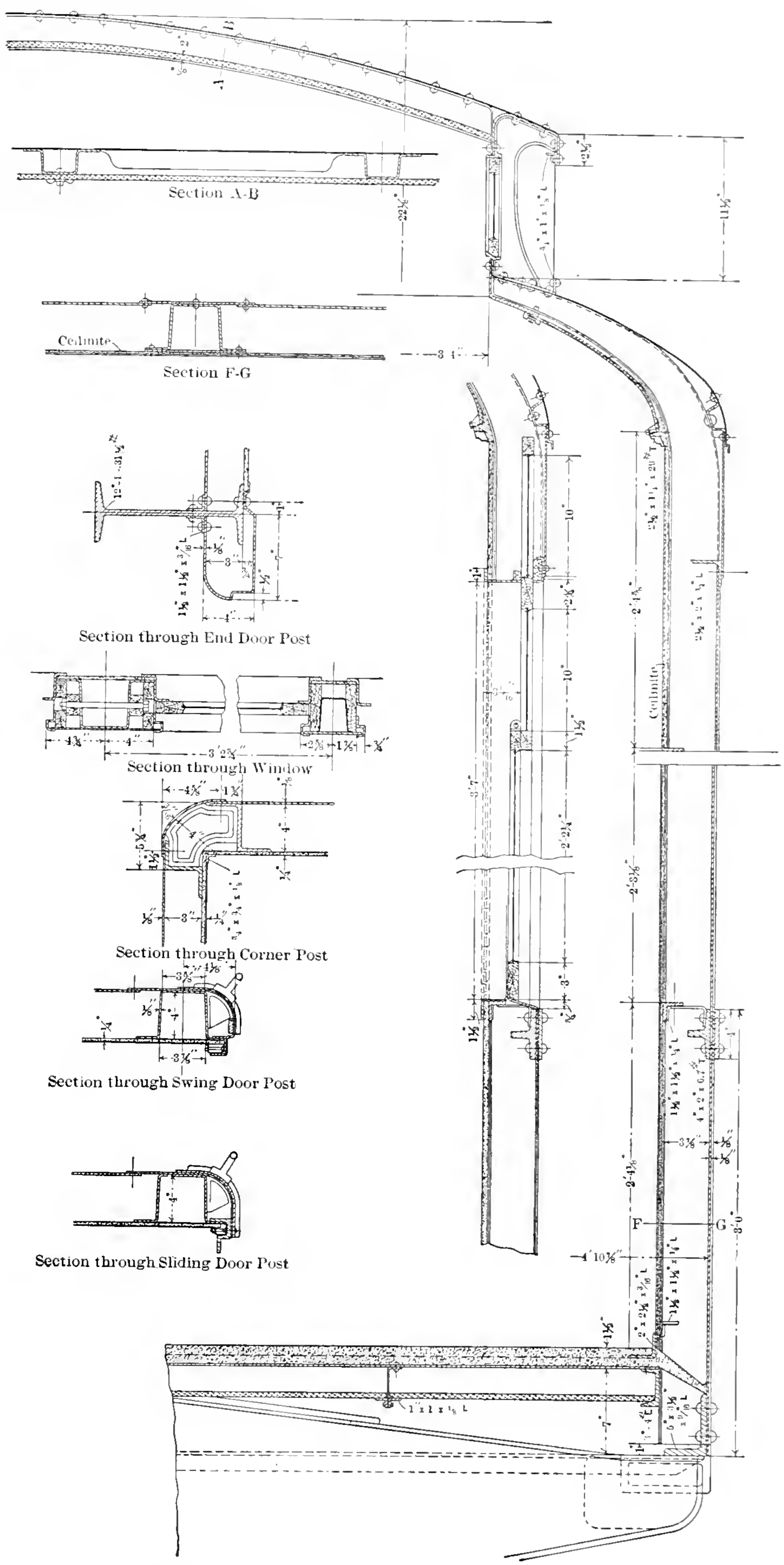
for storage space, thus giving the car a storage space at either end and placing the sorting and distributing sections in the center.

The underframe, which is practically identical with the 70-ft. passenger coach, with the exception of the modifications necessary on account of the omission of the vestibule and side steps, consists of two 18-in. I-beams, with ½-in. cover plates top and bottom, thus forming a box girder center sill which is set at a height above the rail permitting the draft gear to be enclosed in the girder and eliminaing the necessity of auxiliary draft sills. The whole weight of the car is carried on the center sills, being transferred to them by the end sills and by two cross bearers which are placed about 19 ft. from the end sills and about 32 ft. apart. These are made up of pressed steel shapes, with cover plates top and bottom. No body bolsters are required in this design and the center plate is fastened directly to the center sills and the side bearings to the side sills.

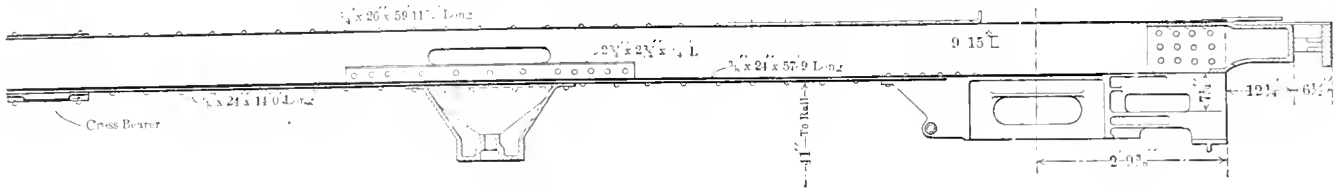
The superstructure is the same as that used on the passenger coaches with the exception that the belt rail is a flat bar instead of a formed section and is reinforced with a T-section between the posts. The end structure also differs somewhat from the passenger coach and is provided with two 12-in. I-beam door posts set with the web parallel to the sides of the car and securely fastened to the end sills and the end plate in such a manner as to make it practically impossible for the superstructure to be swept from its underframe by the adjoining car in the event of a collision. The side posts are of sheet steel pressed in channel section with the edges flanged out to connect with the side sheathing, thus forming a box girder structure. The side posts are narrowed down and bent inward at the top, forming the lower deck carlins. They are connected at the upper ends to the combined deck sill and plate formed of a sheet steel member pressed into a special channel section. The openings for the deck windows are cut in the web of this member, which is reinforced by malleable iron posts of special design between the window openings. The upper deck carlins are of a structure similar to the side posts, being secured to the upper flange of the deck plate.

The side and roof sheathing is of steel plates, the roof being 3/32 in. thick and the side ⅛ in. in thickness. The inside sheathing below the eaves is of 1/16-in. steel plate to the unexposed face of which is cemented 3/16-in. asbestos.

All of the interior furniture is of steel, and conforms to the regulations of the post-office department. The letter cases are built up of steel plates and wire and the larger cases are made of 1/16-in. sheet steel reinforced with angle irons. This car contains but 370 lbs. of wood, is lighted by electricity and heated by steam. It weighs 128,000 lbs.



SECTIONAL ELEVATION AND DETAILS OF FRAMING—70-FOOT ALL-STEEL POSTAL CAR.



CENTER SILL CONSTRUCTION—ALL-STEEL SUBURBAN CAR.

Suburban Car.

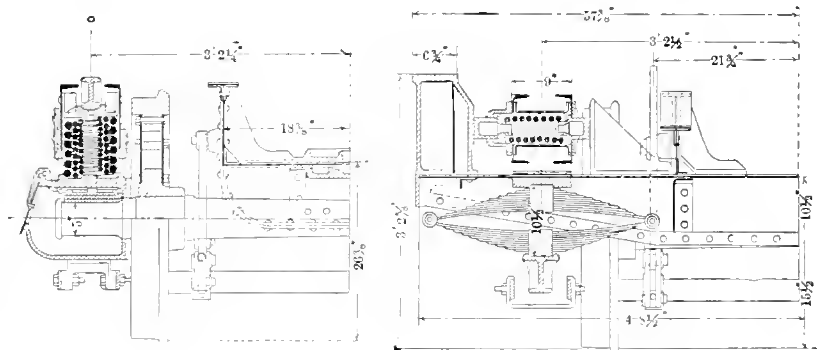
The general structure of this car is the same as for the heavier type of equipment, but the car is lower, shorter, and the space allowed each passenger is less than in the larger cars.

The underframe differs from the heavier equipment principally in the center sills, which in this case are formed of two 9-in. channels with a single $\frac{1}{4}$-in. cover plate on top and two $\frac{3}{8}$-in. cover plates on the bottom. This arrangement is necessary in order to provide room for the motors on motor trucks, which may be used under these cars on electrified sections of the road. This construction makes it necessary to use auxiliary draft sills on these cars, the arrangement of which is shown in one of the illustrations. The center plate is of a special form adapted to reach the same trucks used under the heavier equipment. The upper structure of these cars corresponds very closely with the 70-ft. passenger coach.

Six-Wheel Truck.

The six-wheel truck which is used under the baggage and postal cars is designed along the same lines as were used in the four-wheel truck previously described.

The very deep center sills used on this equipment give the truck center plate but little clearance with the center axle of the truck and much care in designing was required in order to secure sufficient strength. The design adopted, as is clearly shown in the illustration of the truck, consists of built up steel girders resting on the two truck bolsters and carrying between them in the center a short connecting girder, for carrying the center plate, which is built up in channel shape with the lower



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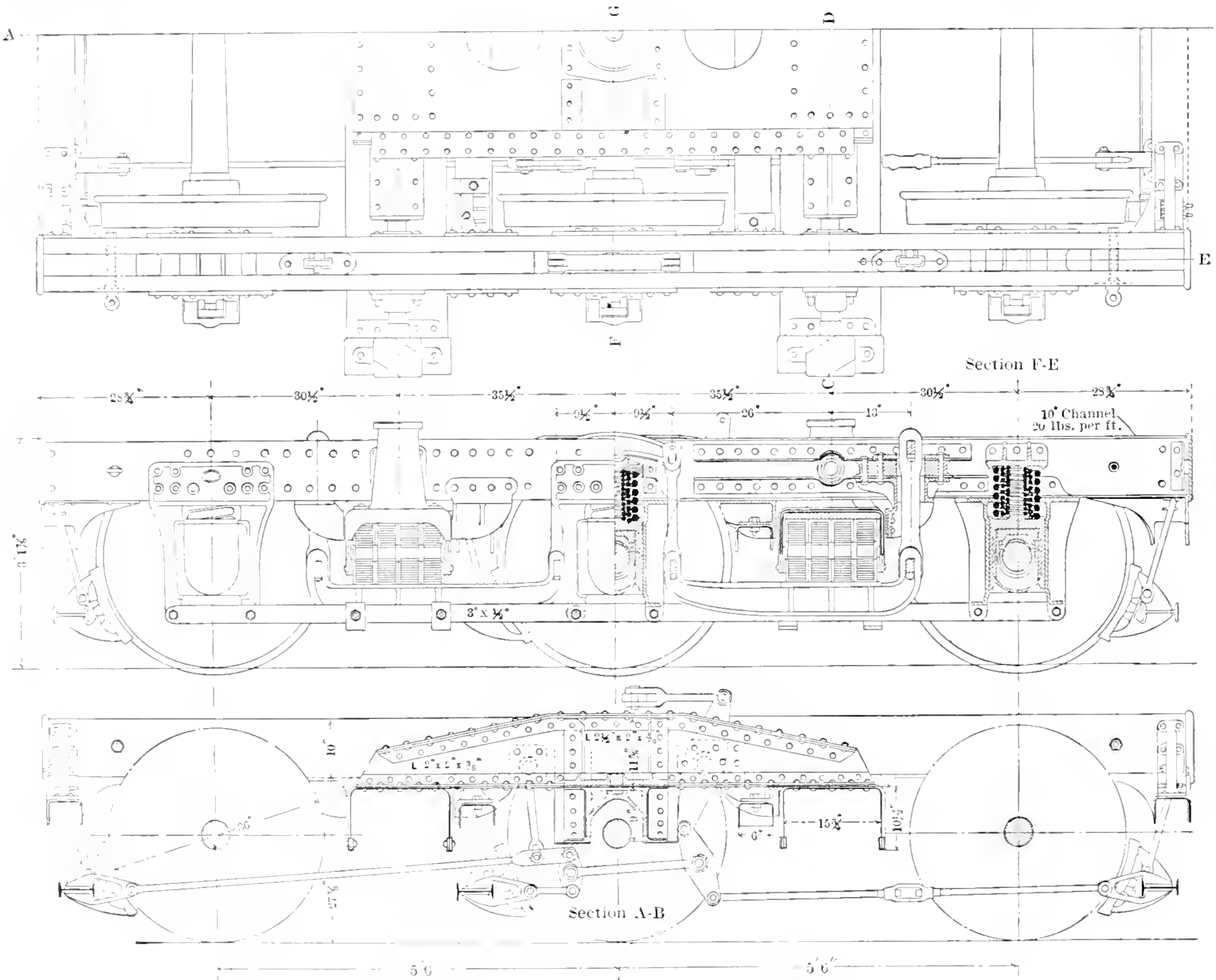
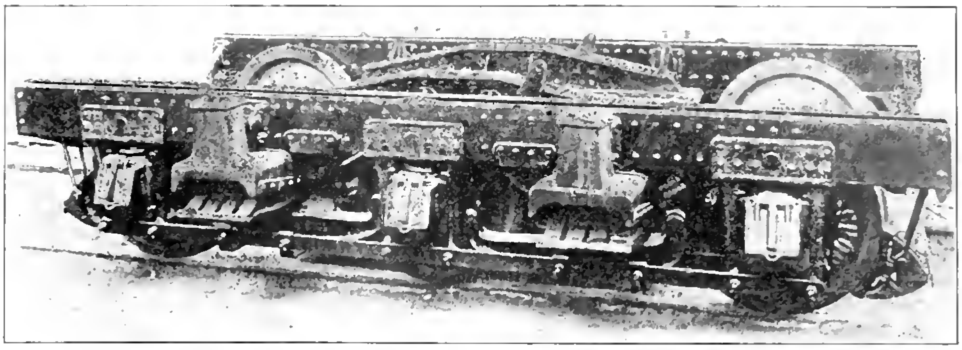


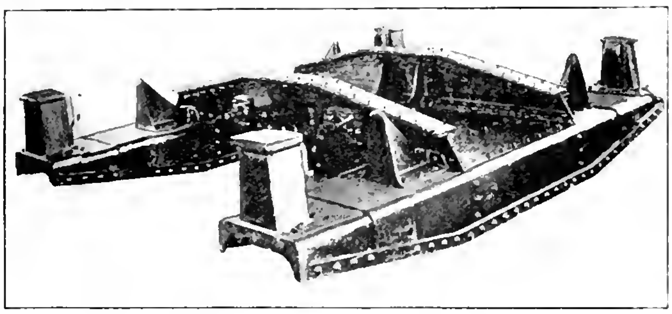
SIX-WHEEL ALL-STEEL TRUCK—70-FOOT POSTAL CAR, PENNSYLVANIA RAILROAD.

flanges spanning the center axle. A heavy horizontal steel plate binds and stiffens this whole structure as is shown in the illustrations. The two truck bolsters are of the same design used on the four-wheel truck and rest on sixteen elliptical springs, four at each end of each bolster. The wheel pieces consist of two 10-in. channels and are spaced and secured by four cross bars of a special pressed steel shape, being dropped down in the center to clear the center sills. The weight is transferred directly to the journals of the outer two wheels through the wheel pieces and the nests of coiled springs on each box in the same manner as for the four-wheel truck. The center wheel, however, receives its load through similar coiled springs, the spring cap of which is connected through a short equalizer by hangers to the 2 : 1 equalizers on which the bolster springs rest. The shorter arm of these equalizers is connected directly to the wheel piece. In this manner each journal box receives 1/6 of the total weight brought to the truck.



SIX-WHEEL TRUCK, STEEL POSTAL CAR—PENNSYLVANIA RAILROAD.

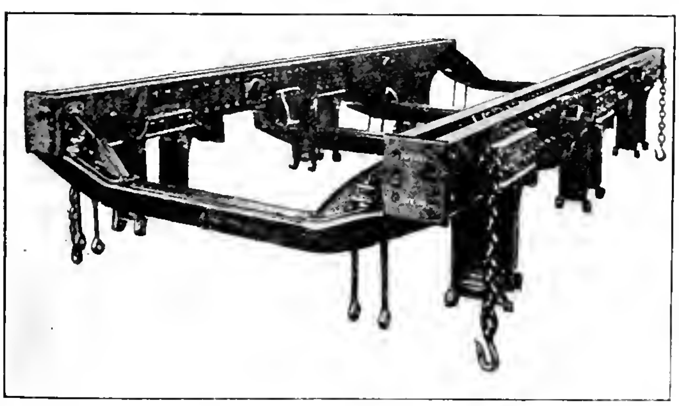
The bolsters have a spring centering device of the same type as used on the four-wheel truck and carry side bearings at their outer ends in a similar manner. This truck requires the use of brake beams, the connections to which, however, are made very close to the brake head instead of at the center as is usually done.



DOUBLE TRUCK BOLSTER—SIX-WHEEL TRUCK.

COUPLER AND DRAW BAR.

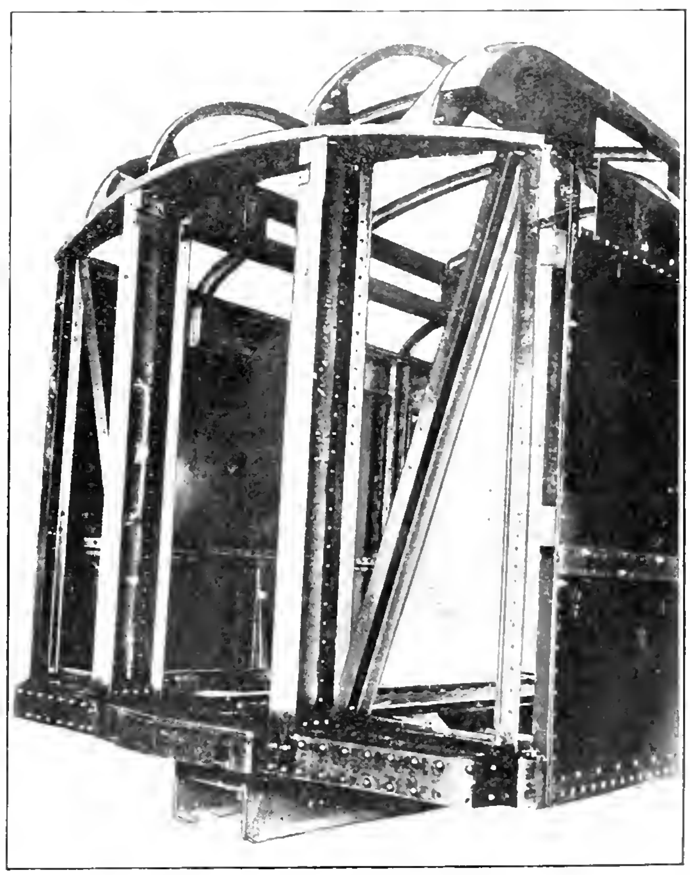
A special design of spring centering draw bar and coupler head has been applied to these cars. This will permit an 8-in. lateral motion of the draw bar on either side of the center without binding. The details of the design are shown in one of the illustrations. It will be seen that the draw bar is pivoted to the yoke at its inner end and to the coupler at its outer end. The socket in the coupler head in which the draw bar enters is broad enough to allow considerable radial movement of the coupler head. Within this socket pivoted around the same pin are two levers, the outer ends of which extend back and rest on a bearing fastened to the webs of the center sills. These two ends are held apart and against their bearing by a large helical spring. Both levers have another arm extending back and bearing on the opposite sides of a pin in the draw bar which is shown just within the ends of the center sills.



FRAME—SIX-WHEEL TRUCK.

The operation of the device is such that a movement of the draw bar as a whole operates through the pin just mentioned to one of the levers and the motion is then transferred to and resisted by the helical spring. The motion of the coupler head in rotating about its pivot is also transferred to these levers by the sides of the cavity in the head coming into contact with the lever and moving it against the resistance of the spring. Thus one spring acts as a centering device for both the draw bar and the coupler head.

To prevent trouble with the uncoupling connections when so large an amount of motion is provided for, they have been carried back to a bell crank pivoted around the inner draw bar pivot and by a series of bell cranks and rods, connection is made to the head and the uncoupling shaft from this point. The steam and air pipes are also connected so as to allow a certain amount of lateral motion and prevent interference with the coupler. They are connected, as is shown in the illustration, by a cast steel yoke having a bearing in lugs secured to the center sills and spanning the draw bar. Helical springs are arranged to keep this



BODY END FRAMING—70-FOOT STEEL POSTAL CAR.

yoke central except when the draw bar has moved a certain definite amount and strikes the yoke carrying it along against the resistance of the springs.

A UNIT OF COMPARISON.*

By Geo. G. Yoemans.†

One of the gravest difficulties which confronts anyone who is attempting to exercise a general supervision over the supply department of a railroad, and to direct its operations without being intimately connected with the details of daily routine, is to determine definitely, and within reasonable limits, whether or not the total amount of supplies carried in stock is greater than it should necessarily be.

In other words, whether the interest charge on the money invested in supplies is warranted expense—and whether or not any portion of the amount so invested could be profitably released and diverted into other channels, where it would bring larger returns, without detriment to the service.

With the best intentions in the world the storekeeper is in the unfortunate position of being thrown in constant contact with those officials whose interests demand that there should always be "plenty" of everything available at a moment's notice, and while one of the fundamental duties of the position is to see that all reasonable demands of this nature are fully met, the daily surroundings of the storekeeper lead him to be on the safe side, and to frequently have more than "a plenty."

* * * * * *

The measure of efficiency in this respect would naturally be the average amount of material carried in stock per something—PER WHAT? Copies of the annual reports of 33 different railroads in all sections of the country were obtained and a number of theories were considered and tested out in an attempt to reach a satisfactory conclusion, but in every instance we seem forced to the opinion that the only measure, which may be considered as approximately meeting all conditions, is the measure of work performed; namely the total number of tons moved one mile, and the total number of passengers carried one mile, added together; and that the percentage which the average amount of stock carried bears to the sum of these two factors expressed for convenience in "10,000 ton and passenger miles" may be considered as a guide to the amount of material necessary to be carried in stock, to meet the requirements of every-day operation.

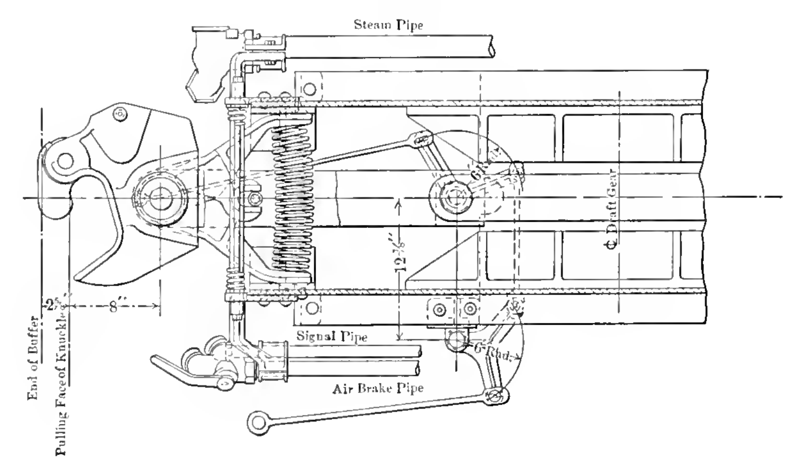
* * * * * * *

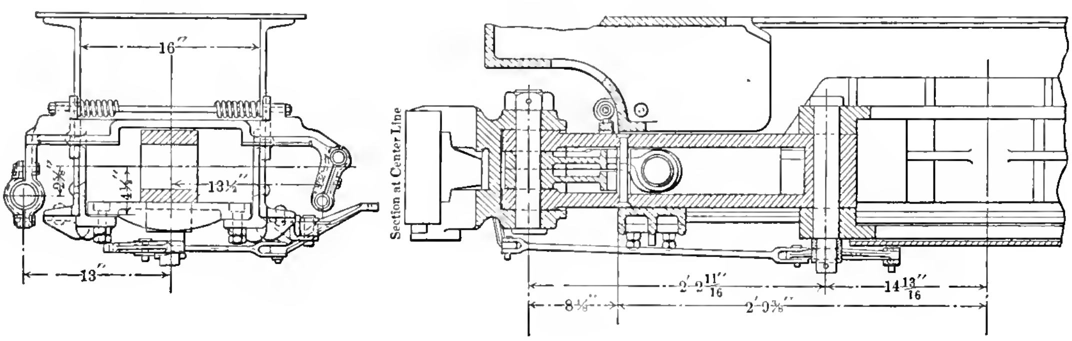
The efficiency of the department must be judged upon the basis of the amount of miscellaneous stock material such as is commonly used in the ordinary every-day operations of the road and there should be no shelter of "extraordinary circumstances behind which the supply agent may take refuge.

Tested by this unit it is surprising to see what a wide variation exists among the leading railroads of the country in this respect, and while a portion of it is undoubtedly due to discrepancies of accounting, more is undoubtedly due to the degree of organization, methods, and efficiency which have been reached by the department in charge of this important branch of the service.

The total amount of money invested in material on the thirty-three roads under consideration is over one hundred and four millions of dollars. As between the two roads which, tested by this method, show the best and the poorest performance, the latter company, if its stock of material could be reduced to the same relative basis as that shown by the former, would be able to release over nine millions of dollars; and if its stock of material was reduced only to the average amount per unit shown as carried in stock by all of these lines, it would still be able to release over six millions of the money it now has so invested, the interest on which is in the nature of a fixed charge against its operation. If the total stock reported on hand by all of the thirty-three railroads could be reduced to the basis of the best performance over sixty millions of dollars would be made available for other uses.

These are startling figures. I do not claim that they accurately represent actual conditions, but I do claim that they clearly point to conditions that actually do exist. Allow, if you please, fifty per cent. of these amounts for discrepancies in the accounting methods on which this comparison is based, and the remainder is of sufficient importance to awaken the interest of managing officials. Don't make the mistake of thinking that this is a little thing. Every hundred dollars intelligently released from unnecessary duty adds at least four dollars to the net income of the company at the end of the year, and the figures I have given indicate the number of times by which it may be possible to multiply that hundred dollars perhaps in your own department.



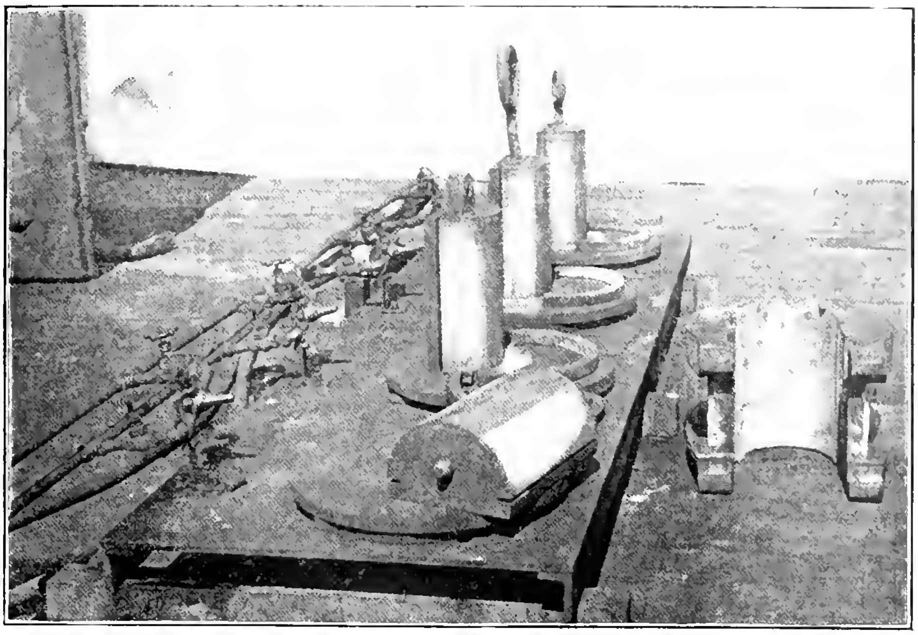


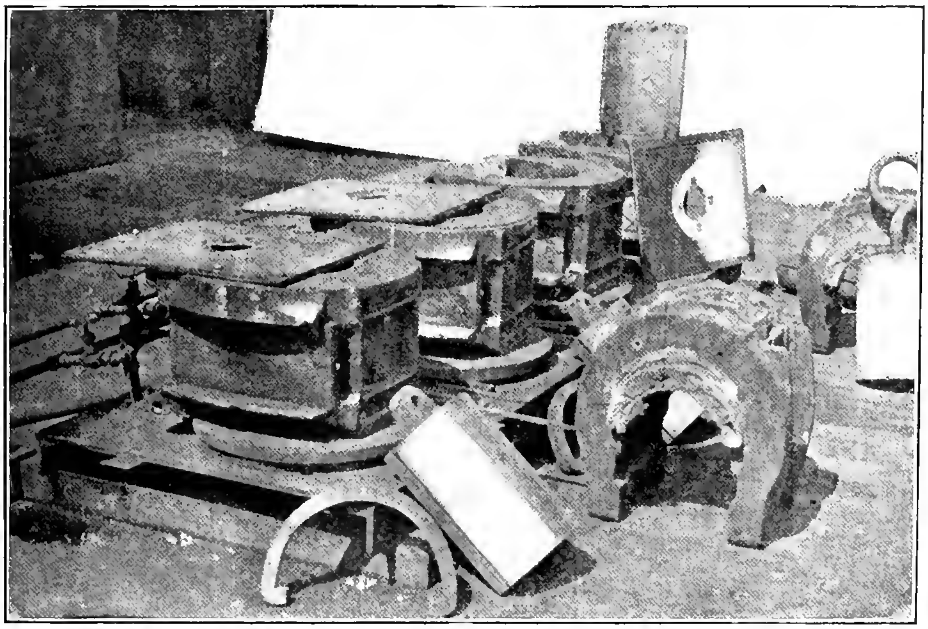
RADIAL COUPLER AND DRAWBAR—PENNSYLVANIA RAILROAD ALL-STEEL CARS.

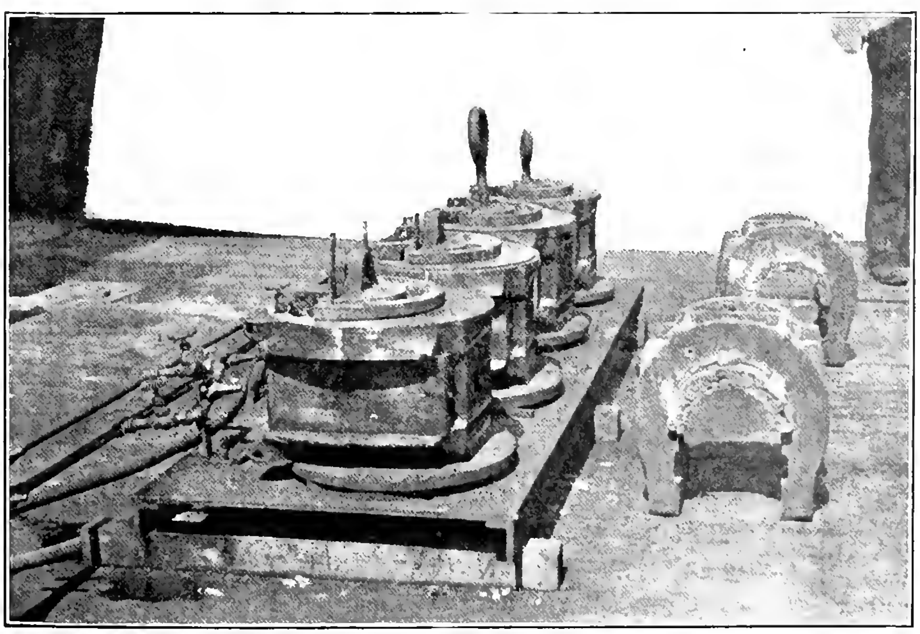
The Pennsylvania Railroad has 45,496 shareholders, the average number of shares held by each being 137.

* Extracts from a paper read before the Railway Storekeepers' Association.

† Assistant to the President, Wabash Railroad.







CASTING SHELLS AND HUB AND SIDE LINERS IN DRIVING BOXES.

Lake Shore & Michigan Southern Railway.

The practice of casting shells in driving boxes was introduced on the New York Central Lines, by Mr. John Hill, master mechanic on the Lake Erie & Western at Lima, Ohio. It is being followed extensively at Elkhart and Collinwood on the Lake Shore & Michigan Southern Railway and is giving very satisfactory results.

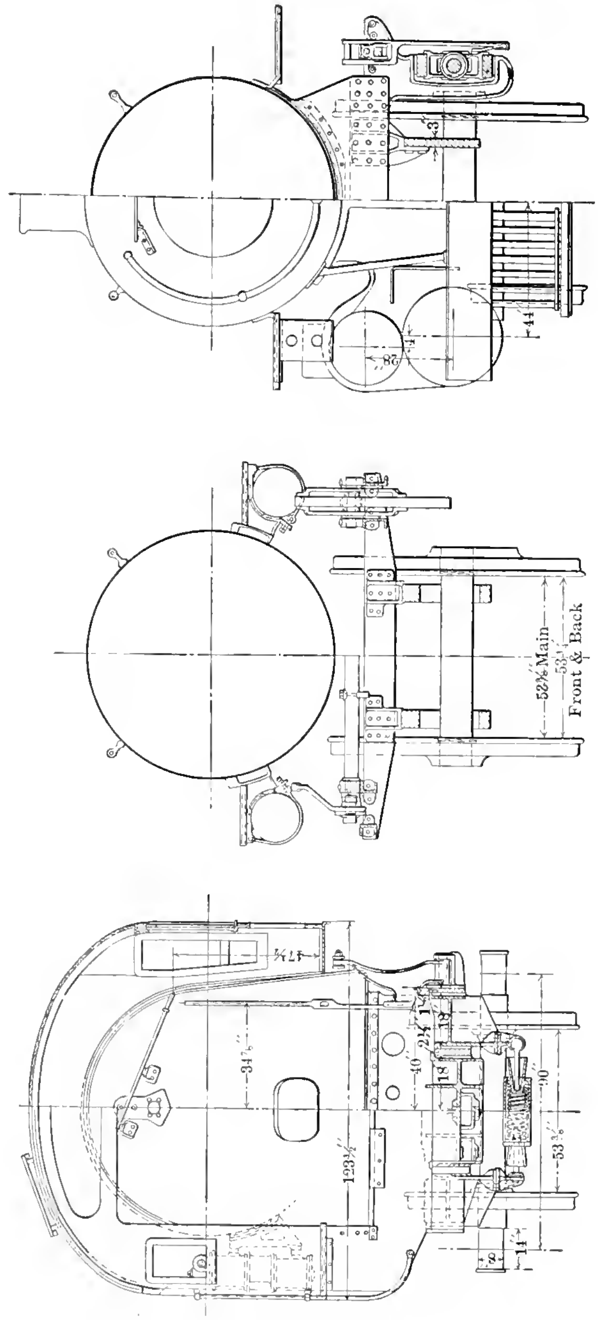
The apparatus used is shown in the accompanying photographs. Four cast iron plates, each of which carries a driving box, are placed on the iron table. A hole is bored in each plate to receive the pin on the end of the mandrel. The driving box is centered about the mandrel by tapered wedges driven into the slots in the mandrel and coming into contact with the sides of the box. After the box is properly centered the mandrel is lifted out and the end of the box and the upper side are partially covered with sheet iron pieces. A flame from the crude oil burner is then directed inside the box, heating and drying it out thoroughly and expanding the open ends from 5/16 to 3/8 of an inch.

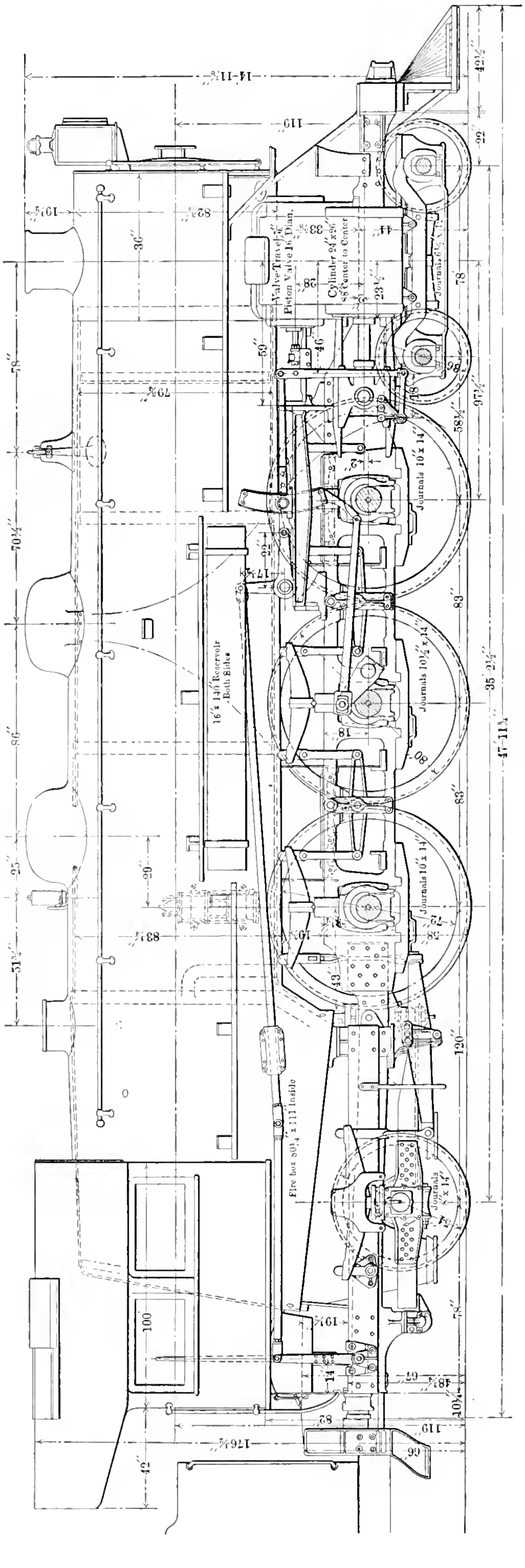
The mandrel is replaced and the wedges are driven home without changing the original position of the box. A wrought iron riser is then placed on top of the box, as shown. The metal is poured in at this top opening and as soon as it is set, but before the box cools, the riser and mandrel are knocked out of place. On boxes where it is necessary to use a hub liner the riser is made of a large enough diameter to equal that of the outside hub liner and the shell and the liner are poured at the same time and are in one piece. The box is then placed in an upright position. Cast iron formers are placed the proper distance from the shoe and wedge bearing faces and the side liners are cast in the same way as the shells, thus doing away with the necessity of machining the box or of riveting.

The crown of the box has five dovetail cuts in it into which the metal runs when the shell is poured. The function of these dovetails is to draw the brass close to the box. From 80 to 100 tons pressure are required to press the shells out of the box. These dovetails also make it possible to draw the open ends of the box together when the brass cools, which is exactly opposite from the action when brasses are forced into the box according to the usual method. The free opening at the top when the brass is poured allows the gases to escape and the metal mould cools the alloy instantly, preventing segregation. A fracture of the metal poured in this way shows a clearer, closer grain compared to the same metal poured in a sand mould. There is, of course, a

considerable saving of labor over the old methods. A number of heavy locomotives have been in service on the Lake Erie and Western with driving boxes fitted in this manner and the brasses have worn to ⅞ of an inch in thickness without becoming loose in the box. It allows the use of cracked boxes which could not be used with the pressed shell.

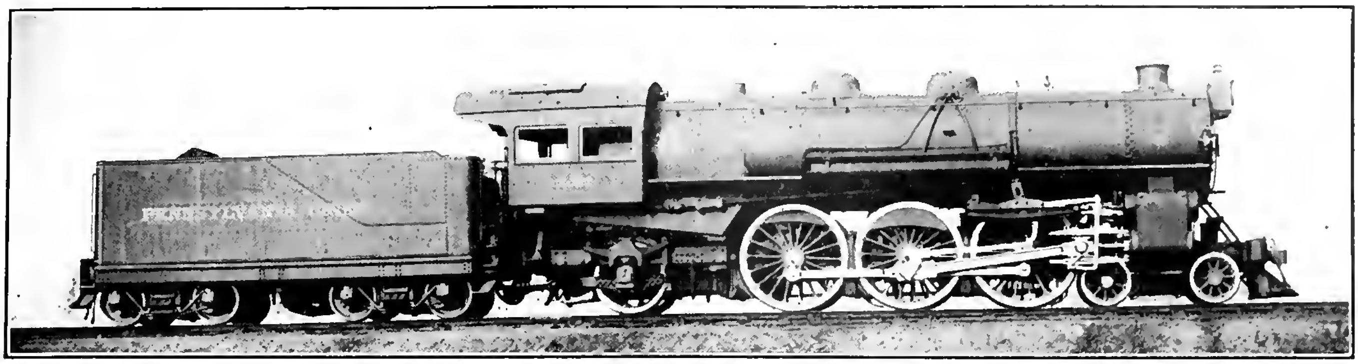
Coaling Direct from Cars.—Where the quantity of coal handled is small and especially at terminal points where the engines lie over night and the coaling can be done by the hostler or watchman, coaling direct from the cars is the cheapest. This work can be helped by elevating the track, on which the coal cars stand, from two to four feet above the locomotive track.—*Report of Committee, Amer. Ry. Eng. & M. of W. Assoc.*





ELEVATIONS AND SECTIONS OF 135-TON PASSENGER LOCOMOTIVE—PENNSYLVANIA RAILROAD

Laboratory for Testing Explosives.—The United States Geological Survey, within a few weeks, will establish, probably in the Pittsburg district, an experiment station for the purpose of testing explosives used in coal mining, the ultimate object being, if possible, a reduction in the number of mine disasters resulting from gas and coal dust explosions. Miners' safety lamps will also be tested at this station, and explosive investigations will be conducted both in the laboratory and in the mines.



HEAVIEST PASSENGER LOCOMOTIVE EVER BUILT—PENNSYLVANIA RAILROAD.

LARGEST PASSENGER LOCOMOTIVE, 4-6-2 TYPE.

PENNSYLVANIA RAILROAD.

The American Locomotive Company has recently completed at its Pittsburg works a Pacific type locomotive for the Pennsylvania Railroad, which in point of size and weight exceeds any passenger locomotive ever constructed. It weighs 269,200 lbs. total, has 24 x 26 in. simple cylinders, a 79¾ in. boiler, 21 ft. tubes, 61.8 sq. ft. of grate area and carries 205 lbs. steam pressure. The tractive effort, because of the large drivers and lower steam pressure, is not as great as that of the 2-6-2 type balanced compound on the Santa Fe,* but exceeds all other passenger engines on our records. The accompanying table will permit comparison of the general dimensions and ratios of this and four other recent large passenger locomotives.

Road	P. R. R.	A. T. & S. F.	N. P.	L. S. & M. S.	Erie.
Type	2-6-2	2-6-2	2-6-2	2-6-2	4-6-2
Simple or comp.	Simp.	Comp.	Comp.	Simp.	Simp.
Total weight, lbs.	269,200	248,200	240,000	233,000	230,500
Wgt. on drivers, lbs.	173,550	174,700	157,000	165,200	149,000
Tractive effort, lbs.	32,700	37,800	30,340	27,850	30,300
Size of cylinders	24″ × 26″	17½″ & 29″ × 28″	16½″ & 27½″ × 26″	21½″ × 28″	22½″ × 26′,
Diam. drivers	80″	69″	69″	79″	74″
Steam pressure, lbs.	205	225	220	200	200
Tot'l heat surf., sq. ft.	4,427	4,020	2908.8*	3,905	3,326
Length of tubes	21′	18′ 10 5/16″	16′ 9″	19′ 6″	20′
Grate area, sq. ft.	61.8	53.8	43.5	55.	56.5
B. D. factor	590.	650.	720.	565.	669.
Tot'l H.S. ÷ grate area	72.	74.	67.	71.	58.7
Total H. S. ÷ vol. cyl.	326.	334.	294.	335.	277.
Tot'l wgt. ÷ total H.S.	61.	62.	82.5	61.	69.5

* Combustion chamber 3′ long.

The standard passenger locomotive of the Pennsylvania Railroad has been, for many years, the Atlantic type, of which there are several classes in operation. The largest of these, known as the E3D, has 22 x 26 in. cylinders, 80 in. drivers, 67 in. Belpaire boiler, and carries 205 lbs. steam pressure. The tractive effort at 85 per cent. boiler pressure being 27,500 lbs. It has Walschaert valve gear and piston valves.

These locomotives have been able to satisfactorily handle an eight-car passenger train over divisions where there are many difficult grades. However, as many of the passenger trains now require ten, twelve or more cars, making them altogether beyond the limit of the Atlantic type unless the weight on drivers was increased above practical figures, it was decided to design a Pacific type engine which would be able to handle the heaviest trains on these divisions. While but one of this design has at present been built it is expected that, after a careful working out of this one, more will be ordered.

The general features of the design will be evident from an inspection of the general elevation and the table of dimensions given below. A number of the details will be illustrated and separately considered in the next issue.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Soft coal
Tractive effort	32,700 lbs.
Weight in working order	269,200 lbs.
Weight on drivers	173,550 lbs.
Weight of engine and tender in working order	409,200 lbs.
Wheel base, driving	13′ 10″
Wheel base, total	35′ 2½″
Wheel base, engine and tender	67′ ¾″

RATIOS.

Weight on drivers ÷ tractive effort	5.30
Total weight ÷ tractive effort	8.22
Tractive effort × diam. drivers ÷ heating surface	590.00
Total heating surface ÷ grate area	72.00
Firebox heating surface ÷ total heating surface, per cent.	4.65
Weight on drivers ÷ total heating surface	39.20
Total weight ÷ total heating surface	61.00
Volume both cylinders, cu. ft.	13.60
Total heating surface ÷ vol. cylinders	326.00
Grate area ÷ vol. cylinders	4.56

CYLINDERS.

Kind	Simple
Diameter and stroke	24″ × 26″

VALVES.

Kind	Piston
Diameter	16 in.
Greatest travel	7 in.
Outside lap	1 5/16 in.
Inside clearance	¼ in.
Lead in full gear	¼ in.

WHEELS.

Driving, diameter over tires	80 in.
Driving, thickness of tires	4 in.
Driving journal, main, diameter and length	10½ × 14 in.
Driving journals, others, diameter and length	10 × 14 in.
Engine truck wheels, diameter	36 in.
Engine truck, journals	6½ × 12 in.
Trailing truck wheels, diameter	54 in.
Trailing truck, journals	8 × 14 in.

BOILER.

Style	Straight
Working pressure	205 lbs.
Outside diameter of first ring	79¾ in.
Firebox, length and width	111 and 80¼ in.
Firebox plates, thickness	⅜ and 9/16 in.
Firebox, water space	4½ in.
Tubes, number and outside diameter	343—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4,222 sq. ft.
Heating surface, firebox	205 sq. ft.
Heating surface, total	4,427 sq. ft.
Grate area	61.8 sq. ft.
Smokestack, diameter	22 in.
Smokestack, height above rail	180 in.
Center of boiler above rail	119 in.

TENDER.

Tank	Waterbottom
Frame	Steel
Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	7,000 gals.
Coal capacity	11 tons

* See AMERICAN ENGINEER, Nov. and Dec., 1906, pages 434, 481.

ERECTING SHOP FLOORS.—Floors with a top wooden surface are much to be preferred, as they are more agreeable for the men standing upon them. This floor, however, must be protected from rot by a proper substructure. A recent specification called for the ground to be well tamped to a level 14 inches below the finished floor line and then covered to a depth of 6 inches with broken stone, the voids being filled with small stones and the whole being well rolled or rammed into place. This surface was to be liberally covered with hot coal tar, and after setting, it was to be brought to a level by one inch of sand and tar, the sand being heated and thoroughly incorporated with a mixture of two parts of coal tar and one part of coal tar pitch. On this were to be placed 3 x 4-inch yellow pine zinc-treated sills, the spaces between the sills being filled with tarred sand and packed while hot to a level with the top of the sills. Over this was to be laid a course of 2¾-inch treated yellow pine, this being covered with a layer of roofing felt, and finally a course of 1¼-inch hardwood boards. While such floors are expensive they are very permanent, and we have heard of cases where they have been in use for twenty or thirty years.—*Mr. G. R. Henderson at the New England Railroad Club.*

HARRIMAN LINES ALL-STEEL POSTAL CAR.

STEEL POSTAL CAR

HARRIMAN LINES.

In the January, 1907, issue of this journal there were illustrated the details of an all-steel 60-ft. passenger coach, designed and built by the Southern Pacific Company at the Sacramento shops. The same company has recently completed an all-steel postal car, which in general features of construction follows very closely the principles used in the passenger coach.

The underframe of this car consists of two 12-in. I-beams as center sills and two ½ x 3½ x 7 in angles as side sills. These members are continuous between end sills. The center sills are trussed by two 1½ in. truss rods passing over the top of the bolsters and connecting to steel castings on the end sills. The center and side sills are tied together between the bolsters by 5 in. channels set with the web vertical and secured to the sills by 2½ x 2½ in. angles. These are spaced approximately 2 ft. apart. The sills are further tied together by the needle beams, which are built up of ¼ in. web plates and 3 x 3 in. angles into an I-beam structure. A ¾ in. cover plate passes continuous over the top of the center sills and a ½ in. plate forms a bottom cover plate and extends continuous between the side sills below the center sills. The underframe is stiffened by four sets of diagonal braces consisting of 5 in. channels arranged and connected as shown in the illustrations. The body bolsters are double and of cast steel and are constructed to fit around the center sills.

The side framing consists of 2½ x 4 in. posts extending between the side sills and the plate, which is a 4 x 4 in. angle continuous the full length of the car. These posts are spaced as shown in the illustration and are stiffened by 2½ x 4 in. angles set between and connected to each, forming the belt rail. Diagonal braces of 2 x 2 in. angles are fitted on either side of the door openings as shown. The end framing is composed of rectangular plates ½ x 3 in. to which heavy [illegible] are riveted and extend from end sill to end plate. The end door framing is constructed of two [illegible] angles forming a Z-bar and adding materially to the strength of the end construction. Further strength and stiffness is obtained by the placing of a 5/16 in. plate 2[illegible] in. wide horizontally across the car and securing it to the end and side plates.

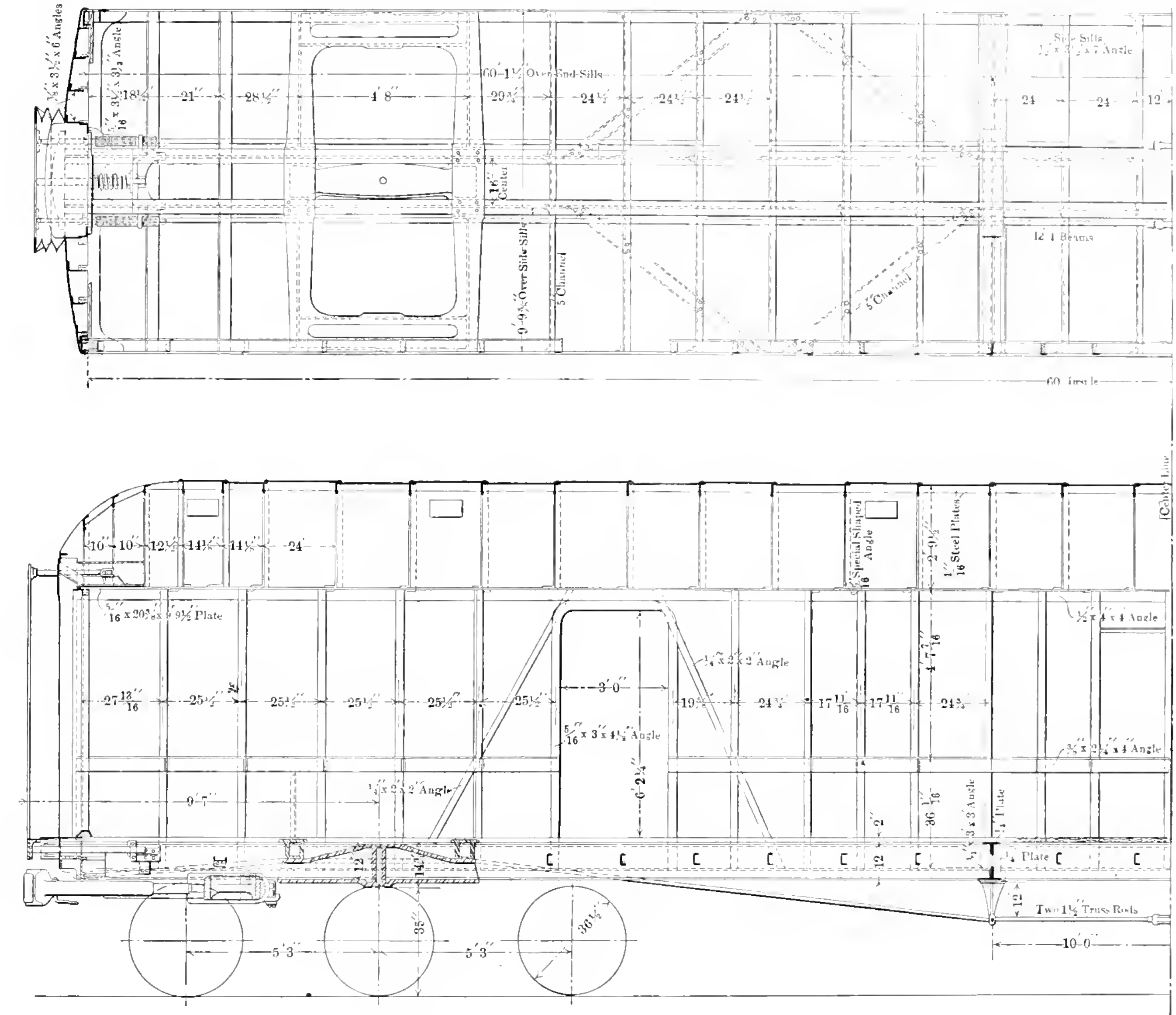
The shape of the roof is elliptical, the upper deck being dispensed with. It consists of carlines composed of 5/16 x 1¾ x 4⅝ in. angles formed to the proper contour and secured to the side plates. The outer roof lining is of 5/16 in. sheet steel, and the inner lining is of similar sheets, which are flanged on the edges and riveted to the carlines, thus forming panels 2 ft. in width. This construction is clearly shown in the view of the interior of the car.

The side sheathing is of 3/16 in. steel plate up to the belt rail and ⅛ in. steel plate above this. A letter board of ⅛ in. steel plate 12 in. in depth covers the joint of the roof sheets with the side sheets. The interior finish is of asbestos board secured to the wooden filling pieces fitted in the side posts.

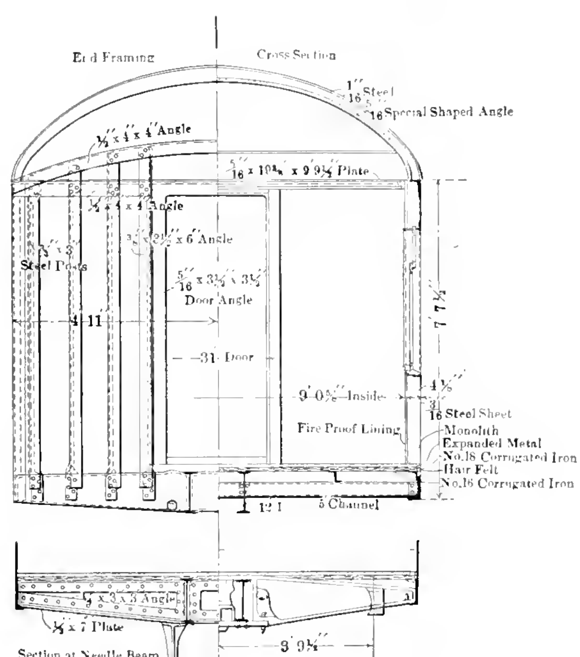
The flooring is formed of two courses of corrugated steel sheets, between which two courses of hair felt are placed. These rest on the center sills and longitudinal angle irons secured to the cross bearers and side sills. A monolithic cement floor is laid on top of the upper sheet.

The lighting is by electricity generated from the axle and the car is heated by direct steam, the system being fitted with an automatic temperature regulator. Cottier ventilators to the number of 14 are fitted in the roof. The car is carried on two six-wheel trucks of the usual Pullman type. The interior is fitted

INTERIOR OF ALL-STEEL POSTAL CAR.



FRAMING OF ALL-STEEL POSTAL CAR—HARRIMAN LINES.



with pouch racks, sorting boards and pigeonholes to suit the Government specifications. The car weighs 116,900 lbs.

The Union Pacific Railway has also recently turned out of its Omaha shops a steel postal car of a design practically identical with the one above described. The service of this car was so satisfactory from the beginning that it has been decided to build thirty-four more of the same type. The contracts for these are now being placed.

VARIABLE SPEED MOTORS ON MACHINE TOOLS.—For driving machinery, motors of variable speed are generally required for individual applications and constant speed motors when a group of tools is driven through a section of shafting. Motors can now be obtained operating upon a single voltage with a speed ratio of 3 or 4 to 1, and in some cases even greater; but for railroad purposes we think that a change ratio of 2 to 1 is generally sufficient, the additional variations being made by mechanical means. This enables one to use motors of a lower price than where a large speed ratio is considered important. It is perhaps only necessary to have the large variable speed ratio where a piece of work has to be faced in a boring mill from a large circumference down to a small central portion, and as such classes of work are rare in locomotive shops there seems to be little absolute need for the higher speed ratios. Three-wire and four-wire multiple-voltage systems have been installed, but we doubt if there is sufficient to pay for the complication in wiring over the single-voltage method of speed regulation by field weakening. Alternating current motors are very satisfactory for constant speed work, but it is often thought advisable to limit the power current in one building to either the direct or the alternating, in preference to having a mixture of the two. —*Mr. G. R. Henderson at the New England Railroad Club.*

(Established 1832).

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Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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COMPARATIVE COST OF MAINTAINING STEEL AND WOODEN CARS.

Through the courtesy of Mr. J. Kruttschnitt, director of maintenance and operation of the Union Pacific System and Southern Pacific Company, we are enabled to present the following comparative statement of the cost of maintaining steel and wooden cars. This statement is for cars of approximately the same age and capacity and covers a period of $2\frac{1}{2}$ years, from September 1, 1904, to February 28, 1907.

Kind of car.	Av. No. of cars	Total cost of repairs.	Av. cost repairs per car per month.
Steel Cars:			
Ballast	460	$71,291.81	$5.17
Box	2,304	108,323.29	1.57
Coal	1,594	165,959.57	3 47
Dump	300	39,322.92	4.37
Flat	2,289	72,024.30	1.05
Furniture	297	32,198.04	3.61
Gondola or Ore	1,419	134,019 10	3.16
Oil	871	261,613.43	10.01
Stock	1,693	55,908.34	1 10
Total	11,227	$940,660.90	$2 79
Wooden Cars:			
Ballast	457	$65,560.89	$4.78
Box	6,247	735,405 53	3.92
Coal	127	14,329.81	3.76
Flat	512	15,699.75	1.02
Furniture	278	61,999.51	7 44
Oil	247	96,910.90	13.05
Stock	2,700	291,940.19	3.61
Total	10,568	$1,281,846.58	$4.04

Of the so-called steel cars the ballast, coal, dump, gondola and ore and oil cars are of all-steel construction; the box, furniture and stock cars have steel underframes; one hundred of the flat cars are all-steel and the remaining 2,189 have wooden floors. The high cost of repairs for the oil cars is due to the fact that alterations which it was found necessary to make on these cars shortly after they were placed in service were charged to the repair account.

CONVENTION NOTES.

The attendance at the conventions was larger than ever before. The meetings were especially well attended and the proceedings were followed much more closely than usual. Care had been taken to eliminate all disturbing noises and the speakers were able therefore to make their remarks more effective than usual. Usually near the close of each convention the attendance begins to fall off, but this year it held up to the very last moment. The exhibits, both as to general appearance and in detail, were far beyond any of the previous ones. This fact was appreciated by the railroad men present, most of whom found it necessary to devote a considerable amount of time to them.

* * * * * * *

It is unfortunate that more younger men did not take an active part in the meetings. Very few of them participated in the discussions. A systematic effort should be made to "line them up" and to develop them for more effective work.

* * * * * * *

The executive committees should see to it that some attempt is made to have the reports in the hands of the members earlier than usual before the next conventions. As it is, and has been in the past, the reports are received by the members too late for them to make a careful study of more than a very few of them before the conventions and they are thus not in a position to discuss them intelligently. The reports should be sent to the members at least 30 days before the convention. Such reports as are not received in time should be held over for a year and the committees should be censured.

Under present conditions the members do not have time to prepare a carefully thought out discussion of the papers in which they are specially interested, but speak on the "spur of the moment." Because of this they do not always succeed in making their meaning very clear and often considerable time is wasted because in the hurried reading of a report they may overlook im-

portant parts or fail to grasp the import of the paper as a whole. Not only should the reports be issued earlier, but those who are especially well qualified to discuss them should be asked in advance to prepare a discussion and if they cannot attend the convention to forward it to the secretary. This will bring out much important data and will also afford a good means of getting the younger members to take a more active part in the work of the associations.

* * * * * * *

The committees gave more attention than usual to presenting the reports in abstract, but there is still much room for improvement in this direction. The suggestion has been made that each committee submit for approval an abstract of its report, suitable for presentation before the convention, at the same time that the report is sent to the executive committee for final approval before printing.

* * * * * * *

Undoubtedly the three most important papers which were considered at the Master Mechanics' Association were the New York Central Lines apprentice system, described in a paper prepared by Messrs. Cross and Russell; the paper on "Shop Cost Systems," presented by Mr. Lovell, and the report of the committee on superheating. That the shortage of skilled labor and the difficulty of securing good foremen is getting to be a serious problem in the mechanical department of our railroads was evinced by the enthusiastic discussion of the apprenticeship question.

It is rather discouraging that there was not a more thorough discussion of Mr. Lovell's paper and it would seem that very few of those present had any idea of its value or broad significance. There can be no question but what the output of a shop depends much more on its organization than upon the equipment and that the only way to make any considerable general improvement in a shop is to bring up the efficiency of each individual in it. The possible returns from this source are many times greater than from anything which can be accomplished by improving the equipment. The Santa Fe has been very fortunate in having evolved a system by which the efficiency of each man in the organization can be accurately determined, either in the shops, or roundhouses, or the efficiency of the shop or roundhouse as a whole can be determined. Possibly this feature may have been considered too briefly in Mr. Lovell's paper and those of our readers who may wish to make a more complete study of it can easily do so by referring to the articles in our June paper on the "Methods of Exact Measurement Applied to Individual and Shop Efficiency at the Topeka Shops of the Santa Fe," by Mr. Harrington Emerson. and "Roundhouse Betterment Work," by Mr. J. F. Whiteford. This question of individual efficiency is not something that is tied up to the bonus system, but it can be worked out easily under other systems, as suggested by Mr. Vaughan in the discussion of the paper.

The report on superheating was a very careful study of the results which have been gained on this continent up to the present time. The discussion was rather disappointing in that so few took part, but this is not to be wondered at when we learn that at the end of 1906 there were only 19 locomotives in the States which were equipped with superheaters and that six of these were on the Rock Island System. The Canadian Pacific Railroad at that time had 176 superheater engines in service and has since received or has on order 170 additional ones. That the application of the superheater to locomotives has been successfully solved and that the credit for adapting it to the conditons met with on this continent is almost entirely due to the Canadian Pacific Railroad and Mr. Vaughan is beyond question. The roads in the States have been very slow in taking this matter up and possibly, as suggested by Mr. Vaughan, this was a wise move on their part, as they were relieved of all the trouble and expense to be met with in developing a feature of this kind for practical use and yet Mr. Vaughan frankly admitted that while the difficulties which were met with on the Canadian Pacific were very great, yet in spite of this the railroad was the gainer from a financial point of view. Now that the Canadian Pacific have paved the way it is to be hoped that the railroads in the States will take advantage of what has been accomplished.

MASTER MECHANICS' ASSOCIATION.

FORTIETH ANNUAL CONVENTION.

The convention was called to order on June 12th on the Steel Pier at Atlantic City by the president, Mr. J. F. Deems. Mr. Deems' address, part of which is reproduced on page 253, was of an entirely different order from that which is customary. No attempt was made to review in detail the work of the Association or to suggest means of solving the present motive power department problems. Mr. Deems confined himself to calling attention to the most important problem before us at this time, that of *men, the training and building up of men for the work of the future.* The address was short, forceful and to the point and was characteristic of the man who made it. It met with the hearty approval and indorsement of those present.

The secretary's report showed the present membership to be as follows: Active, 819; associate, 17; honorary, 4; total, 876. The treasurer's report showed a balance on hand of $2,739.11.

Mr. A. B. Marsh has completed his four years' course in the Joseph T. Ryerson & Sons scholarship at Purdue. This scholarship will be continued for another four years. There are three vacant Master Mechanic scholarships at Purdue University. Beginning with the next college year there will be four Master Mechanic scholarships vacant at Stevens Institute of Technology, Hoboken, N. J. Messrs. J. Snowden Bell and Lawford H. Fry were elected as associate members. Messrs. W. C. Ennis and Henry Elliott were elected to honorary membership.

MECHANICAL STOKERS.—The report was received and the committee was continued for another year. In discussing the report Mr. J. F. Walsh stated that he had found the mechanical stoker necessary and successful with the narrow and long fire-boxes on heavy locomotives in freight service, but that with wide fire-boxes on engines doing the same work it was not necessary.

SHRINKAGE ALLOWANCE OF TIRES AND DESIGN OF WHEEL CENTERS.—The report was accepted and the committee was instructed to prepare its recommendations for letter ballot. The lip on the outside of the tire was recommended because it made a much simpler machine job than when on the wheel center and on the inside. The sudden increase in shrinkage recommended for wheels above 66 in. in diameter is due to the greater elasticity and flexibility of the larger wheel centers.

LOCOMOTIVE LUBRICATION.—The consideration of this report precipitated a lively discussion, mainly as to the recommendations of the committee concerning the number of miles to be run per pint of oil. Several instances were cited of exceptionally good records which had been made, but the general opinion seemed to be that these were due to the expenditure of more time and trouble than could reasonably be expected of the engineer.

APPRENTICE SYSTEM ON THE NEW YORK CENTRAL LINES.—This was the most important paper presented at the convention. The complete paper and the more important parts of the discussion will be found on page 253 of this issue.

SHOP COST SYSTEMS.—The individual paper on this subject, prepared by Mr. A. Lovell, superintendent of motive power of the Santa Fe, was, in his absence, abstracted by Mr. Harrington Emerson. Next to the apprentice question this was the most important subject under consideration and it is unfortunate that there was not a more thorough and complete discussion. That part referring to the determination of the efficiency of the individual workman or of the shop as a whole is of vital importance, and sooner or later our railroad managements have got to come to the full realization of this if they expect to produce the best results. Part of the discussion is reproduced, in connection with the paper, on another page.

SUPERHEATING.—The report was abstracted by Mr. H. H. Vaughan. Mr. C. A. Seley said that his road had made some changes in the arrangement of the Cole superheater, which is now giving satisfactory results.

Mr. Vaughan said: "This question of superheating is developing rather peculiarly. We are in it very heavily. At the end of

this year we shall have about 375 engines equipped with superheaters, all big engines; and in the States, while there have been a few spasmodic instances, nothing at all has been done on any large scale. In my opinion the roads in the States have done very wisely. We have had a great deal of trouble in our experimental work with superheaters. We have made money, but we have had a lot of things to find out. I believe inside of another year we can definitely and reliably say that you can equip engines with superheaters, and if you will give them attention—not expense, but attention—you can run without any more trouble than you have with the ordinary simple engine. I would like to emphasize the difference between attention and expense. If a device is put on an engine and when an engine comes in and a damper packing is leaking, and a man goes to work and sticks a gasket in the joint, and the round-house foreman sees the damper is not working, and lets it go, and the flame is going through the tubes, and they deteriorate at the return bend, and then a return bend blows off and it is necessary to take down the headers and cut the engine out of service, and the transportation department says, as I heard one man say,—"We call them freezers, not superheaters,"—that all comes from lack of attention. It would not have cost five cents to have replaced the packing right in the first place. If we are going to give up a device that will save from 10 to 20 per cent. on coal just because we cannot get round-house machinists and foremen to pay attention to things, we are going on the wrong track. It is a question of attention with superheaters, and not of expense."

"We have the records from passenger service of the number of failures, and of these failures a large number came from the use of bronze nuts. There are only three failures that are serious in 198,000 miles. That shows definitely, I think, that you do not have enough engine failures with superheaters to condemn them. The road records show that they do make a satisfactory saving in coal. Therefore I think superheating is a thing that is worthy of careful attention and should be taken up properly. I would like to call one more point to your attention. We frequently hear it stated that our coal only costs us $1.50 or so and it is hardly worth our while to go to the superheating, almost always forgetting that coal that costs $1.50 originally may not cost $1.50 where it is burned. It costs money to haul coal to the place where it is burned. There are many roads showing coal at $1.50 on the performance sheets, that are hauling it 300 and 400 miles before it is used. You cannot haul it much under one-half a cent per ton per mile and that runs up very quickly, and there are very few roads that cannot afford to spend $800 or $1,000 on a new engine."

"Since going to superheating we have reduced the pressure on all our new engines built, to 180 lbs., increasing the size of cylinders in proportion, and so far as we can see, with equally satisfactory results. We are going to derive the benefit from decreased boiler troubles, and get the same economy, and just as lively an engine."

In reply to a question from Mr. A. W. Gibbs as to the size of piston valves and forced lubrication, Mr. Vaughan said: "We use a 11-inch piston valve for a 21-inch cylinder, and we have since enlarged that cylinder to 22½, and still use the 11-inch valve, with results entirely satisfactory. I have had a feeling though that we have gone about as far as is necessary in putting an 11-inch valve on a 22½-inch cylinder. Of course that is a considerably smaller valve than you would use in general practice with saturated steam. Forced lubrication I do not believe to be necessary. I think the sight feed lubricator works better on a superheated engine than on a saturated engine."

Cause of Leaky Flues.—Mr. M. E. Wells in opening the discussion of his paper called attention to a letter from Mr. W. H. Lewis, stating that nearly one-half the engines came in dry but leaked after they were placed over the cinder pit because of filling them up with cold water.

Mr. E. P. Roesch (Southern) stated that flue leakage increased in the same ratio as the number of times the fires are knocked or the boilers washed. He mentioned several tests which he had made, one of these being as follows: "We took an ordinary wide firebox locomotive with 385 flues and put it over the cinder pit and knocked the fire. Preliminary to this test we opened up the front end and cleaned off one flue and arranged a long piece of wood, with a micrometer attachment in the rear end of it. After the fire was knocked it still had 135 pounds pressure, or 358 degrees of heat. The length of the flue was taken, and at the same time this length was scribed on the side of the boiler. After the engine stood quiet for three hours and fifty minutes without any water being injected into the boiler, the pressure had dropped to six pounds, or 230 degrees tem-boiler had contracted just an even sixteenth inch in the length, corresponding to the length of the flue, and the flue had contracted 3/32 inch, showing that the flue, through the action of the air through it, had contracted more than the boiler itself. After the engine stood two hours and thirty minutes longer the pressure had dropped to six pounds, or 230 degrees temperature. We found then that the boiler had contracted 14/64 inch while the flue had contracted but 9/64 inch, showing that owing to the difference in the amount of metal in the boiler and flues, the final contraction of the boiler was greater than that of the flues, and produced a pushing and pulling action.

Proper Spacing of Flues in High Pressure Boilers.—The report was read by Mr. C. E. Fuller, following which Mr. Tonge presented a supplementary report including an account of the saving which had been effected on one road by a redesign of the flue spacing in its locomotives.

Mr. Wells said that he believed there was no question but what wider spacing of the flues was an advantage, particularly with poor water.

Mr. Gaines drew attention to the fact that by the use of a smaller back end on the flues, all the advantages of the wider spacing were obtained. He also mentioned that a too generous use of the rollers was responsible for much flue leakage. Mr. West stated that his road was following the methods recommended by Mr. Gaines with much success.

Mr. W. Forsyth stated that the facts brought out in this report had been known for several years, and it was peculiar that the builders still used the narrow spacing. He suggested that careful tests should be made on the matter of flue spacing and the evaporation from flues of varying lengths.

Mr. F. H. Clark reported that his experience had been that wider spacing did not always result in improvement, and that other affecting conditions should be considered.

Mr. Vaughan stated that flue spacing was largely a matter of conditions. Engines with narrow bridges run satisfactorily in good water districts, but bad water districts required wider bridges. He believed that a mistake was made by heavy prossering of flues in bad water districts, as this gave an excellent opportunity for the accumulation of scale and neutralized the benefit of the wider bridges. He advised doing away with prossering altogether in bad water sections. He did not agree with the idea of using fewer flues to save the cost of safe-ending them; the boiler should have all the flues possible so long as the circulation is not interfered with. Mr. Vaughan also opposed the idea of going to the expense of making careful tests on this subject, as he did not believe that such tests could be made with sufficient accuracy to give results of value. He instanced the St. Louis tests as an example.

Mr. Wagstaff agreed with Mr. Vaughan in that each different set of conditions required different treatment. He said that flues were like other things, in that good care would give equally good results.

Mr. W. Forsyth moved that a committee be appointed to ascertain the most economical spacing of flues in locomotive boilers, and the relative value of the heating surface of flues of different lengths.

This motion was opposed by Mr. Vaughan for reasons as stated above; also by Mr. McIntosh on the same grounds. The motion when put to a vote was lost. The committee was continued another year.

Results of use of Different Valve Gears.—The report of the committee was read by Mr. Seley.

Mr. Gaines brought up a point in favor of the Walschaert gear, in that on his road it had become necessary to relieve the engineers of responsibility for inspection at points where there

were no inspection pits, because of the impossibility of their getting underneath the engines.

Mr. E. A. Miller stated that during four months he had had 12 failures of valve gear on 15 engines equipped with the Stephenson motion and only 1 failure on 10 engines with the Walschaert gear.

Messrs. Manning and McIntosh reported entire success with the Walschaert valve gear engines on their roads. These cover practically all types with both piston and slide valves.

BLANKS FOR REPORTING WORK ON ENGINES UNDERGOING REPAIRS.—The report of the committee was read by Mr. Pratt.

Mr. Gaines stated that no form was provided for showing daily how many engines were ready for service, and how many in shop and for what class of repairs. He considered that such a blank should be provided.

Mr. Harrington Emerson spoke, in part, as follows: "In looking over the repairs of a large railroad company, we find that certain divisions will suddenly go all to pieces, they would apparently be in first-class condition, and inside of thirty days there was no motive power available, all the engines in the shop virtually. That was the kind of thing we ran up against on our road, so a method was devised that took the matter very largely out of the hands of the operating officials as far as information was concerned. Every single engine was put on an efficiency basis, in the same way that the men were put on an efficiency basis. The average of all the engines on the division had to average 100. If they did not average 100, it was evident that the engines were dropping backward, and we would find ourselves in a hole. If on the other hand the engines averaged more than 100 on the monthly average we knew the conditions as to that division were satisfactory. In connection with that the tonnage by months for a series of years was plotted in connection with each particular division, so that it was possible to say, without asking anybody whatever, in a general way, exactly the period of the year when all the engines on any particular division would be required for very heavy service, and also the particular time of the year when it would be convenient to shop more engines from a particular division than at some other period.

"Working along these lines it has been possible to plot the efficiency of the engines at any moment whatever, the efficiency of all the engines on the division, and plan months ahead as to just exactly how many engines should go into the shop and to tell the master mechanic three or four months ahead—you must put so many engines into the shop next August, because if you do not put them in in August you will be in trouble in September or October, and that has introduced an entirely different method from the one with which I was formerly acquainted, for shopping and looking after engines. I believe a paper on that subject by the men who now have charge of the system would be an exceedingly interesting one for this association at some future time."

Mr. Gaines moved that the committee be continued and instructed to investigate what is being done along the lines mentioned by Mr. Emerson. This motion was carried.

DEVELOPMENT OF MOTOR CARS FOR LIGHT PASSENGER SERVICE.—The report of the committee on this subject was read by the chairman, Mr. Ball. The report was supplemented by a brief description of the Kobusch-Wagenhals steam car being built by the St. Louis Car Co. It was announced that the report would be accompanied by a number of illustrations when it appeared in the proceedings.

There was no discussion.

PROPER WIDTH OF TRACK ON CURVES TO SECURE BEST RESULTS WITH ENGINES OF DIFFERENT LENGTHS OF RIGID WHEEL BASE.—The chairman of this committee stated that it was not ready to report and asked that it be continued.

A BLANK FORM TO GIVE A HISTORY OF LOCOMOTIVE MOVEMENT AT TERMINALS.—The report of the committee on this subject was presented in abstract by Mr. Basford. He explained that the blanks and methods advocated should not in any manner be considered as a means by which one department could throw the blame on another. They are intended to assist in reducing delays by the co-operation and mutual assistance of the departments. He also explained that the blanks were not intended for continuous use, but only during periods of congestion when it is necessary to closely follow every locomotive.

Mr. Clark stated that he had a similar set of blanks in use and found them of much value during congestion.

Mr. Parish said that he had found such blanks of so much value during rush times that he believed it would pay to use them all the time.

Mr. Vaughan did not agree with the committee that the blanks should show under the head of "mechanical delay" only unnecessary delay, but thought this column should include all the time the engine was in the round-house.

Mr. Miller explained a blank which he was using with satisfactory results. This gave in some detail the time of the locomotive from the time it arrived in the yard until it was ordered out and left the yard.

Mr. Manchester explained that a similar blank on his road had resulted not only in improving the terminal movement to some extent, but also in showing up the physical shortcomings of some terminals so clearly as to make it easy to get appropriations to improve matters.

Other members reported the use of similar blanks with much success. There was some discussion of Mr. Vaughan's point of placing all the time at the terminal under the head of "mechanical delay," but no conclusion was reached.

LOCOMOTIVE FAILURES, RECORDS AND RESULTS OF KEEPING THEM.—The paper on this subject by Mr. W. E. Dunham was read by Mr. Pratt.

Mr. Gaines suggested that it might be advisable to appoint a committee to confer with the American Railway Association to determine a correct standard for an engine failure.

Mr. Manchester considered there were many good suggestions in the report, but criticized some of the blanks suggested therein as being too slow of action.

Mr. E. A. Miller stated that on his road a blank had been in use about two years, on which the engineer reported directly to the superintendent of motive power. From this a monthly statement of engine failures showing 87 items was worked up. By this means failures had been reduced 50 per cent. This scheme also included a record of man failures.

Mr. Roope stated that if something was done to avoid engine failures there would not be a need for so many blanks to keep track of them.

SUBJECTS.—The report of this committee was referred to the executive committee.

OFFICERS.—The election of officers for the coming year resulted as follows:

President—William McIntosh, S. M. P. Central R. R. of New Jersey.

First Vice-President—H. H. Vaughan, assistant to vice-president, Canadian Pacific Ry.

Second Vice-President—G. W. Wilden, assistant S. M. P., Lehigh Valley R. R.

Third Vice-President—F. H. Clark, G. S. M. P., Chicago, Burlington & Quincy Ry.

Executive Committee—C. A. Seley (C. R. I. & P.), F. M. Whyte (N. Y. C.), John Howard (N. Y. C.), A. E. Mitchell (N. Y. N. H. & H.)

TOPICAL DISCUSSIONS.

IS IT DESIRABLE TO ELIMINATE WATER GAUGE GLASSES ON LOCOMOTIVES TO ENFORCE THE USE OF GAUGE COCKS?—This subject was opened by Mr. F. F. Gaines, who stated that in his opinion it was desirable. However, there are some features to be considered which might prevent such action. One of these was the legal aspect, as it was understood by the speaker that several States had laws requiring the use of the water glasses. It developed later that New York State had such a law. Mr. Gaines had found that about one-half the engineers on his road preferred the gauge cocks, while the others preferred the glass, and he had not as yet taken any action as to the removal of the glasses.

Mr. E. A. Miller believed that the education of the men had

much to do with the question, as those who were in the habit of using the glasses objected strongly to their removal. A water glass should not show a higher water level than the top gauge cock. He instanced a case where an additional three inches on the glass had resulted in an epidemic of broken pistons due to carrying too high a water level.

Mr. McIntosh stated that this subject had been up for discussion for many years, and read from the proceeding of 1893 a resolution to the effect that water glasses were not necessary.

Relative Merits of Outside and Inside Delivery Pipes in Connection with Locomotive Injectors.—The discussion was opened by Mr. Strickland L. Kneass, who spoke at some length in favor of the inside delivery pipe with the check valve on the back head. The more important reasons advanced were: greater safety to passengers and employees, more convenient location of injectors, no loosening of check valves by creeping of branch pipe, more even distribution of feed water over the flues, and saving in cost of long copper pipe with its bends and fitting.

Corrugated Tubes for Locomotive Service.—This subject was opened by Mr. G. W. West, who said that the corrugated tubes had given excellent service on his road. They made double the mileage of the plain tubes, did not fill up nearly as badly and gave much less trouble with leakage. The locomotive fitted with them threw practically no sparks, and did not burn the paint off the front end as quickly as other locomotives in the same service.

Mr. Roesch stated that his road had a set of corrugated tubes in service, but they had been in use too short a time to give any definite results.

What is the Best Material for Hub Liners for Driving and Engine Truck Wheels, the Best Method of Applying and the Limiting Lateral Play for Such Wheels Before Repairs Are Required?—The secretary read a letter from Mr. J. F. Dunn opening the discussion. This stated that babbit was considered the best metal and should be poured into a recess in the face of the box with dove-tailed depressions on the bottom to hold it in place; 5/8 in. should be the maximum lateral wear in driving boxes and 3/4 in. in truck boxes.

Mr. McIntosh reported success with babbit hub liners, especially with steel wheels.

Mr. Pratt asked information as to what effect different lubricants had on the best material for this purpose, stating that he had had difficulty with friction at this point when using grease in driving boxes.

Mr. Walsh stated that he had abandoned babbit and gone to bronze for hub liners, because of the low melting point of the former and the impossibility of keeping it in place when using grease.

Mr. Roesch reported the same trouble.

Mr. Minshull and Mr. Roope reported good success with babbit, the latter drawing attention to the fact that babbit should in all cases be sweated on the box.

Other members reported success and failure with both babbit and bronze, and the subject seemed to hinge on the service the locomotive was in, kind of lubrication and method of applying the liners.

Mr. Franey described the method of pouring the crown brass and liner at one operation, which is in use on his road, and is described in detail in an illustrated article elsewhere in this issue.

The subject was finally disposed of by a recommendation that a committee be appointed to report next year.

Abstracts of Reports and Individual Papers.

Shop Cost Systems and the Effect of Shop Schedules Upon Output and Cost of Locomotive Repairs.

Individual Paper by A. Lovell, Supt. M. P., A. T. & S. F. Ry.

The problem of determining shop costs is a very intricate one, and one that railroads in general have not gone into in detail. Keeping trains moving and handling the business presented has so fully occupied the time of railroad officials that the problem of determining cost accurately has been left for a future date.

The general principles have been: Get the engines through the shop, keep the pay-roll down, and do the business. Increased capacity has been more important than superior economy. Some roads undoubtedly are better than others in some things, but a comparison of cost sheets will show such decided differences in cost that the only conclusion to be drawn is that different methods are employed in determining costs.

As far as shop costs are concerned, differences as to engine repair costs may arise from doing a large part of the labor of finishing material on shop or store orders. When an engine comes into the shop, this finished material is drawn from the store department and applied to the engine. The value of this will then all appear as material, and the labor cost of the engine getting the finished material will be reduced a corresponding amount. As an example, the total cost of engines, including labor and material, through two large shops of different systems for the same month was as follows:

	Labor.	Material.	Total.
Road "A"	$21,667.10	$22,323.64	$43,990.74
Road "B"	28,259.64	15,180.49	43,440.13

The total output of engines was practically the same in each shop and the total difference in cost of engines was only $540.00 on the month's output, yet on one road the labor charge was $6,592.00 less than on the other. This is probably a case where there was a difference in the method of determining costs.

SURCHARGES.

The surcharge or amount to add to the direct labor charge is another item of variance. Every road distributes direct labor or pay-roll to engines and shop orders. This is easy. Almost all roads add something to this to cover expense of handling. Some roads are looking into the question of going still further and adding to the cost of the shop output all the items of cost that make up the total expense of running the shop. This is an intricate problem, and, while all agree that items such as rent, supervision, machinery, power, heat, light, water, etc., enter into the cost of the shop output, few are attempting to distribute these items.

Railroads determine costs principally for the purpose of making comparisons between different shops on their lines and also to compare costs in the same shop from year to year. A commercial concern must distribute all its costs to the value of the output so as to determine the selling price. Railroad shop accounting from the mechanical standpoint is different. The railroad is only after a comparative figure to compare one year with another or one shop with another. If the cost of running the power plant is kept as a separate item, we can follow this from year to year and bring pressure to bear to improve it when possible. There is no reason why this item should enter into the cost of repairing engines unless it is desired to compare the cost of what is being done in the railway shop with the price for which some outside concern is willing to do the same work.

It would be well if the cost of the output was determined accurately and scientifically; but as the railroad shops can continue to run efficiently without taking up this special matter, and as no two experts agree as to the best method of actually making the distribution of the surcharge, it is not likely that the matter will be taken up very seriously for some time to come. It is an accounting matter and does not affect relative costs of repairs at different periods and shops on any one road.

Repair shops having been built, the machinery installed and the power plants running, the expense of maintenance will continue as a constant charge; and it is immaterial, as far as comparative costs are concerned, whether they are divided into small quantities and distributed, or allowed to remain in one lump sum. The objects of making a complete distribution of all surcharges, then, is to determine the advisability of buying certain few articles on which manufacturers may desire to compete, and also to determine the economy of purchasing new machinery, making shop extensions, etc.

In its present stage this is a matter for the accounting department to thrash out. When accountants are more united as to how all overcharges should be handled, it will then be proper to take the matter into more earnest consideration. For the present, officers of the mechanical department are principally concerned in keeping the pay-roll down and increasing the number of engines turned out of the shops, resulting in a reduction in repair cost per ton mile of traffic handled.

STANDARD UNITS OF SHOP OUTPUT.

Another point in the matter of accounting that all are trying to solve is a fair unit of shop output on which to base costs. The number of engines turned out, which is the unit commonly used, is misleading and crude, as some engines require more work than others, some are heavier than others; no two, in fact, require exactly the same units of work to be performed on them. A solution of this is to determine total output of the shop in standard units, a standard unit being the amount of work that a standard workman performs in one hour. This determination of standard units performed necessitates complete schedules of every job, but instead of having the schedule show price per job, these schedules show standard units or hours per job.

To determine the total standard units or hours of output the schedule or standard times on every operation performed must

be added together. Having determined the standard units of output, we can also determine the efficiency of the shop, as the ratio of actual hours worked to standard units or hours turned out is the efficiency of the shop. This gives a perfect basis for comparing one shop with another, one gang with another or one individual with another. The diagrams shown represent graphically standard units or hours and actual hours worked, Fig. 1 for a complete shop by months, Figs. 2, 3, 4 for individual workmen by days.

ENGINE SCHEDULES.

Scheduling of engines through shops will have a decided influence to keep everything moving and save delays due to one department waiting on another. Engine schedules must be made very carefully. It is as much of a task to make out the

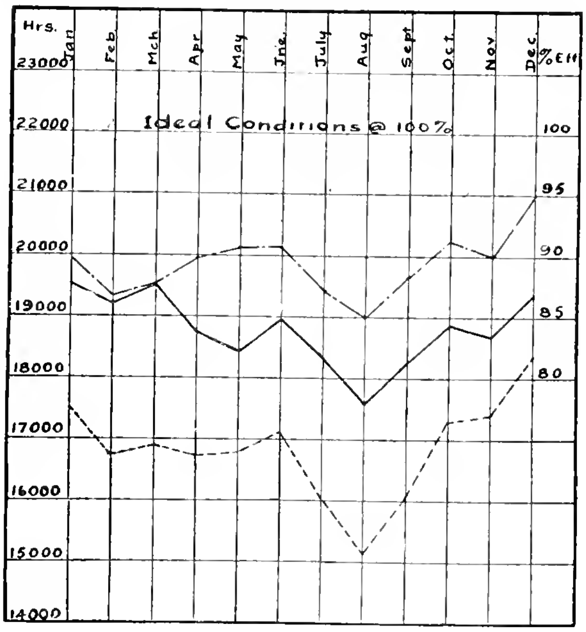


FIG. 1.

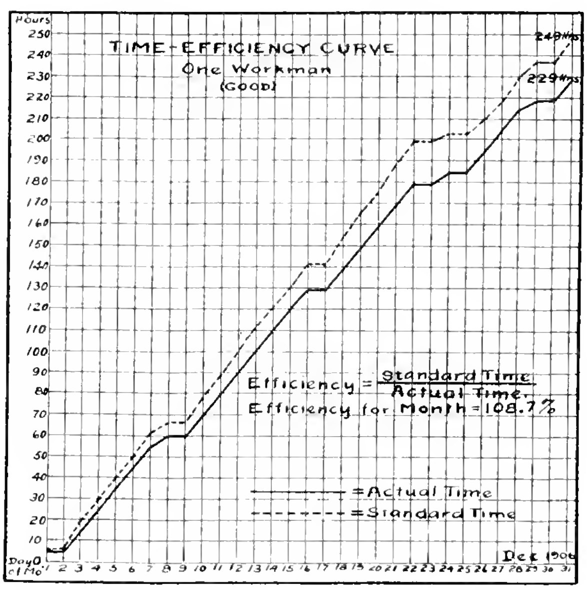


FIG. 2.

schedules for a shop as it is to make out the time card for a division. The schedules that work satisfactorily in one shop will no more apply to another than time cards can be exchanged. Care must be used or some one gang or machine will be crowded with more work to be done at one time than it is possible to accomplish. This brings about a condition somewhat analogous to that on a single-track road when an effort is made to put too many trains on the same siding at once. It cannot be done, and, instead of keeping up to the schedule, everything will be delayed until the necessary switching and see-sawing has been accomplished and the track is cleared.

Engine schedules bear the same relation to getting work through the shop that time cards do to getting trains over the line. Every possible effort is made to live up to schedule, but when everything goes wrong, the dispatcher, in the case of trains, and the general foreman, in the case of the shop, must take a hand, devise new meeting points, hold some trains back, advance others—in fact, run everything special until business is straightened out once more. It is no more possible to keep every engine in a big shop moving on schedule time than it is to keep every train between Chicago and New York on time. If it is found that engines are continually behind schedule, it may be due to two causes: First, the schedules are so fast that it is impossible to live up to them; second, something is wrong in the shop and needs bolstering up. The experience of those who have scheduled engines through a shop is that schedules are of little use unless some real and earnest effort is made to live up to them.

The work on engines is never twice exactly alike; also the men in the shop are continually changing. Both of these conditions tend to prevent an even movement of engines through

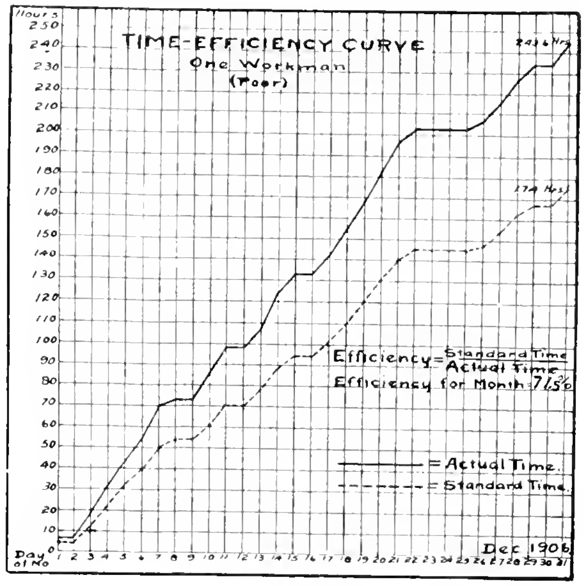


FIG. 3.

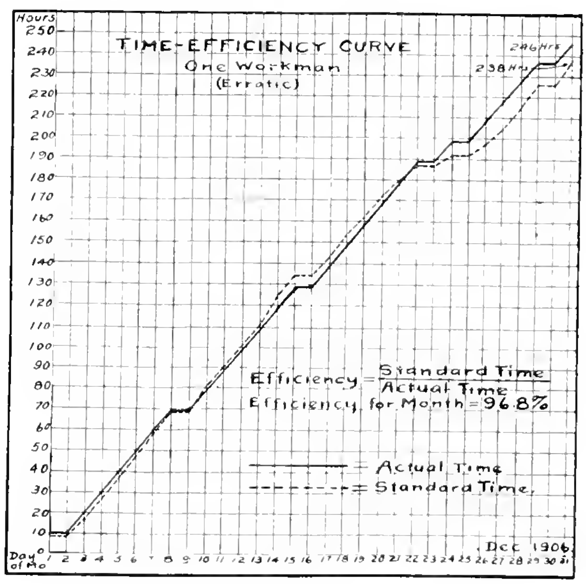


FIG. 4.

the shop. The best solution of this matter of varying amount of work on the engine and of varying numbers of men to do the work is to have a floating gang composed of all-around mechanics to act as a balance wheel for the whole shop. This gang should be used to jump in and bring any engine that is behind schedule up to date.

In some shops it has been found well to have this extra gang work at night; in others it works during the day. In either case it should have a light repair, unscheduled engine of its own to work on, in case it is not needed to bring some laggard up to the mark. It is only by having a floating gang to act as a balance wheel, that the work can be kept moving smoothly through the shop. One road using this system has three classes of schedules and every engine entering the shop is placed on one of these schedules.

Schedule No. 1 for light repairs: Light repairs consist of minor repairs, the cost of which, including labor and material, is more than $50 and less than $500.

Schedule No. 2 for heavy repairs: Heavy repairs consist of thorough overhauling of machinery and such boiler work as can be done without placing the engine in the boiler shop. Cost of heavy repairs, including labor and material, more than $500 and less than $1,200.

Schedule No. 3 for general repairs: General repairs consist of thorough overhauling of machinery and applying a new firebox, or other such heavy boiler repairs as may require the engine to be placed in the boiler shop. Cost of general repairs, including labor and material, to exceed $1,200.

Even with these three classes of schedules there are some adjustments required for special cases. Many times it is the train problem over again and our train has on a few extra cars. All that can be done in such cases is to do all possible to keep up to schedule, and when there is a general falling down, leave matters to the train dispatcher or shop foreman to get the train or engine through the best way possible.*

The shop using these schedules is operated by the gang method and each foreman has a card showing when his particular work is to be done. At 7 o'clock each morning a written notice is handed to each foreman showing how his work stands and a summary is given to the general foreman showing how all the work stands. The general foreman is also given a report showing how many and what class of workmen each gang is short. By comparing the work report with the labor report he is able to assign men from the floating gang to gangs that are liable to fall behind. This method passes engines through the shop with the regularity of mail train service and, combined with a system of rigid inspection and assignment of work gives the minimum delay with the minimum cost for repairs.

Scheduling of engines:

1. Saves confusion and bunching of work.
2. Aids the general foreman to exercise a much better supervision over gangs that are in trouble.
3. Prevents waste of energy by one gang doing work at a time, or in a way, that will interfere with other gangs.
4. Permits the placing of responsibility immediately and correctly on the gang or gangs responsible for an engine delay.

Scheduling in itself will not reduce costs except to the extent that false moves are cut out, and, in general, increased shop output or efficiency means reduced cost. Scheduling does, however, reduce costs when supplemented by the following system of keeping account of labor charges.

Each engine coming into the shop is thoroughly inspected to determine what repairs ought to be made. The inspector's report is made out, showing in detail just what each gang is to do. In addition, the cost of this work is estimated in detail for each gang.

The work to be done by each gang is written up and handed to the foreman. The following is a copy of the work slip given to the foreman of the guide and piston gang for Engine 429 passing through the shop for general repairs in February:

WORK TO BE DONE ENGINE 429, GENERAL REPAIR.

Guide and Piston Gang No. 21.

"Order new right piston complete; right front cylinder head and both right cylinder casings; material now on shop order. Bore both cylinders; just clean them up. Order new left piston complete; crosshead keys; new nuts on crosshead pins; new side liner on crosshead; all new cylinder packing. New piston rod packing and vibrating cups. Hang the guides; put in pistons and see that they have proper cylinder clearance. Put up heads and casings. Put oil cups on guides."

All the gangs in the shop are numbered. (See AMERICAN ENGINEER, September 1906, page 338.)

The timekeeper charges all of the floor time to both engine and gang numbers. When the engine leaves the shop the cost of each separate gang is figured as soon as possible and a report† furnished the shop superintendent, showing the total gang charges to each engine, together with estimated charges. This furnishes him with just the data needed in order to determine which gangs are spending money economically and which are wasteful. He has the estimate of what each gang should have cost and the record of what the gang did actually cost. When there is a discrepancy, the foreman is called to account.

The gangs are held down very rigidly and not allowed to do any work not called for on their work slip. If a gang foreman finds, after the engine is in the shop, some work to be done not called for by his work slip, he must report this to the inspector, who will allow and authorize an extra expenditure to cover the extra work, if he deems it necessary. It is by this close watch that a large saving in labor can be effected, as it prevents unnecessary work being done and makes the inspector responsible for everything done to the engine. Foremen who are inclined to build an engine like a watch are restrained, while those who are inclined to slight their work are spruced up.

The scheduling and keeping track of costs as described above means increased output, because the individual worker is being watched more closely. He is not forced to work any harder than without it, but is prevented from making false moves, getting in the way of other workers, and from doing unnecessary work. The total output of the shop is the sum of the output of each individual worker. This should constantly be borne in mind and no system adopted that will not help each individual worker, as he is the man on whom the output depends.

* EDITOR'S NOTE: At this point a complete outline of the three schedules is given. These cover practically every detail job to be done on an engine.

† For copy of one of these reports see AMERICAN ENGINEER, December, 1906, page 473.

Abstract of the Discussion of Mr. Lovell's Paper.

Mr. Harrington Emerson.—In the absence of Mr. Lovell, I have been asked to abstract this paper. The reason is, probably, that for three years I was intimately associated with him in this work in his department. It is a welcomed opportunity to express publicly the great obligations I am personally under to him for what was finally accomplished. Some men are of assistance by helping one to build up and do right; others are of not less valuable assistance in preventing one from going wrong. Mr. Lovell has one of the keenest minds I ever met in detecting the weak spots, the faulty links in any plan, and time and time again, his criticisms made it necessary to pause, to start over again, to amend and to correct. Mr. Lovell was from Missouri, he had to be shown, but when at last he was convinced, there was no one more willing to support, to defend if need be, than himself. This paper of his outlines some fundamental principles on which we finally agreed, and rejects others that he is not yet prepared to accept. Without disloyalty to him I may in the discussion be permitted to come to the defense of what he is still unwilling to accept.

You will notice from the diagram that the efficiency of the shop has theoretically been increasing from August to December, it being 85 per cent. in August and 95 per cent. in December. This is an ideal diagram, not based on actual facts. Now, any system whatever that will produce that kind of result is a good one, and it is not necessary that it should be any particular kind of system, but it is essential if the efficiency of a shop is to be improved that there shall be some method of showing the relation between what actually is and what should be, and that is defined as shop efficiency.

I now take up those matters in which I dissent somewhat from this report. "In its present stage this is a matter for the accounting department to thrash out. When accountants are more united as to how all overcharges should be handled, it will then be proper to take the matter into more earnest consideration. For the present, officers of the mechanical department are principally concerned in keeping the pay-roll down and increasing the number of engines turned out of the shops, resulting in a reduction in repair cost per ton mile of traffic handled."

The trouble in a great many shops is that neither the foreman nor anybody else knows the cost of the operation, doesn't know whether it is more economical to employ a cheap man that takes a long time, or to employ a high-priced man, who takes a short time; doesn't know whether it is more economical to do work on a cheap machine that takes a little longer or to do it on a very expensive machine that takes a shorter time, and the consequence is that in a great many shops recommendations are made in the hope of accomplishing economy that have exactly the opposite result, that after these so-called improvements have been put in, the costs instead of going down are found to have risen very materially.

It seems to me that to turn the matter of shop administration over to accountants is a very serious and grave mistake. The accountant has a very important duty to perform. He has been trained to account for where the money goes to but "efficiency" is not any part of his duty. The superintendent of the shop should aim at efficiency, and it is no part of his duties to follow up particularly how the money comes in or how it is spent, provided he realizes a high shop efficiency. I could well imagine on a rifle range that the man keeping the score would keep the same kind of a score whether the rifle carried a hundred yards or a thousand yards. The score in each case would be similar. But there is a tremendous difference in the value of the two rifles, whether they shoot straight at a hundred yards or at a thousand yards.

The method of determining costs is important. The cost consists of material, of labor, of machinery and of a departmental charge. Now, unless you know as to every single item that is worked upon or done, the cost of the material in it, the cost of the direct labor, the cost of operating the machine that is used on it and the general costs of the department, it is impossible to tell whether one method is better than another; whether you shall charge a little more for interest or depreciation or a little less is unessential, but unless you have a correct method of determining the actual cost of each unit of work it will be absolutely impossible in any shop whatever to bring costs down to the lowest possible point.

Mr. H. H. Vaughan (C. P. R.)—It appears to me that Mr. Lovell has described a system of shop costs—I do not know whether it is new to all the members, but it certainly is very new to me—which is one of the neatest and most complete arrangements that has ever been brought out, to my knowledge, in the direction of keeping track of men's efficiency. He has supplied

the key to make one of these operation cost-systems practical and useful by taking the standard time or cost on each job, and compiling the figures for each man each month, and then for all the men each month, and thus we have a system which appeals to me probably equal to any piece-work system we could devise. In a good many of our smaller shops piece-work systems are difficult. The work comes along in such a way that it does not allow of piece-work systems being satisfactorily introduced, and those shops are being judged very largely on their output of general repairs, or output of intermediate repairs.

We have never had a system for keeping track of each man's efficiency, or each gang's efficiency, in the way that this system does. I think this is one of the most remarkable papers that we have ever had in that sense. It shows us a way of inherently and systematically following a man's output and a shop's output in a way in which we have never been able to do it before by building up from each unit a completed work. It is worthy of very careful study, and for my part, I do not see why a road that is working some shops piece-work and other shops day-work, could not use this system to put their piece-work prices right into the day-work shops and have some measure of these smaller shops.

With regard to the surcharge question, I can see what Mr. Emerson means about the value of really getting into the surcharge. It seems, however, that railroads are being run to a certain extent different from manufacturing concerns. Our accounts are dominated by the general accounts of the road; the distribution of these accounts is pretty well determined by the Interstate Commerce Commission, and we have certain accounts, such as superintendence, fuel and light for shops, repairs to tools and machinery, etc., which are separate from the repairs to locomotive accounts by general agreement. Now, where these accounts can be best distributed in proportion to the labor, there is, I think, no object whatever in railroad accounting in adding that on to the cost of the work.

The thing that Mr. Emerson brought out, which I agree with him is of importance, is a record of the investment and cost of operating tools. I think very frequently when we get expensive bar lathes in a shop, our foremen are very apt to put work on an expensive machine and be proud to do it in 25 minutes, instead of an hour and a half in a lathe, when the cost of that machine altogether eats up the saving in the cost of labor. To that extent I agree with Mr. Emerson. I do not believe, with most of us, it is of much value in prorating on to the work those items that can only be carried as a percentage of the labor. It is easier to determine what they come to in a month, and if you are in competition with building establishments, as we are, and desire to know whether we produce our work more cheaply, we can take these percentages and add them to our cost, and determine whether it pays to make material or not.

Results of Use of Different Valve Gears on Locomotives.

Committee—C. A. Seley, chairman; R. Quayle, L. H. Turner, J. H. Manning.

As this Association was favored at its last convention with an admirable mathematical analysis of various forms of valve gear in use on locomotives, it is evident, from the wording of the subject assigned to this committee, that it is desired to present the practical considerations governing present-day locomotive engineering in regard to choice and design of valve gears and the results obtained in general practice and use. The subject is, perhaps, the least understood of all the detail mechanism of the locomotive, and while most railroad and drawing offices can produce men competent to lay out and design the ordinary type of motion, yet the builders are very generally called upon to furnish the design, subject possibly to a specification that allows and expects the builder to use his best judgment in regard to these important details. That this confidence is not misplaced is to be seen daily in the fine performance of engines the country over, in all classes of service, fast and slow, passenger, freight, work and switching.

The Stephenson link motion has held its own in this country, almost without consideration being given to other types, until within very recent years. The types and weights of engines employed lent themselves to convenient use of this type of link motion which has many desirable and valuable features to commend it.

The time came, however, when it became expedient to make changes for some of the following reasons: Some types of engines have so many wheels or they are so closely grouped that it is a difficult matter for enginemen to get under them except when over a pit. This contributes to neglect, lack of prompt adjustments for wear, lack of proper inspection and a more rapid deterioration. With the increase in size and weight, the dimensions of eccentrics required for large axles are excessive and their peripheral speed is so great as to make maintenance and lubrication of the eccentrics and straps expensive and troublesome.

By the abolition of eccentrics and straps, a long list of engine failures is eliminated; expense for maintenance and lubrication reduced; room gained for better cross-bracing and strengthening of frames and adding to convenience on account of the men not being required to go under the engines to the same extent. On heavy engines, the weight of all moving parts of a link motion, from the eccentric straps through to the valves, is so great as to contribute to accident and rapid wear so that an equally efficient valve motion with lighter parts and greater accessibility is in demand for heavy power.

For many reasons, we cannot lower the standard of efficiency as set by the Stephenson link motion. Economy in use of coal and water are more necessary than a reduction in weight and wear of valve motion parts. No railway manager will sanction the use of a device, no matter how beautifully simple it may be, if his costs as measured in coal are increased thereby. Fortunately, we are able to obtain a valve motion having the desirable features of lighter parts and accessibility without a loss of efficiency in the Walschaert motion, which has come into extensive use the last few years.

At this point in the report valve motion diagrams were introduced, made by a special machine devised by the Baldwin Locomotive Works. These clearly showed that, notwithstanding the constant lead of the Walschaert motion, the pre-admission is more favorable at short cut-offs than with the Stephenson motion. This data also showed that the various points of pre-admission, port openings, equalization of cut-offs, release and the closures can be as favorably arranged with Walschaert motion as with the link motion examples presented.

The following tables of weights are given us for a 22-inch consolidation engine, said to be identical in everything except the valve motion, built by the Baldwin Locomotive Works:

	Complete Moving and Structural Parts.		Moving Parts Only	
	Stephenson.	Walschaert.	Stephenson.	Walschaert.
Crossheads	676	746	676	746
Guide bearer	814	1,116	....	....
Guides	1,712	1,712	....	....
Eccentrics	600	....	600	....
Crank arms	....	250	....	250
Eccentric straps	1,100	....	1,100	....
Main crank pins	520	516	520	516
Links	238	418	238	413
Reverse shaft	325	655	325	655
Rockers and boxes	618	730	618	730
Rocker rods and hangers	169	....	169	....
Link bearing	....	234	....	....
Eccentric rods	184	264	184	264
Valve rods	220	546	220	546
Valve yokes	154	140	154	140
Valve rod guide	24	28	....	....
Complete set	7,354	8,321	4,804	4,265

These figures indicate that while the valve gear on the engine with the Walschaert motion weighed 1,000 pounds more, yet the weight of the moving parts was less. The AMERICAN ENGINEER AND RAILROAD JOURNAL of June, 1905, published some figures showing saving of weight by the use of Walschaert motion on L. S. & M. S. engines, as follows: 1,283 pounds on a consolidation, 1,215 pounds and 1,745 pounds respectively on two classes of Prairie type engines. These figures indicate a larger saving than the foregoing example, but it is possible that as these were early developments, they may not be representative of present successful practice. It is a fact that similar valve motion parts on engines abroad are very much lighter than we dare use in our own practice. It seems fair to conclude, therefore, that we may yet look for improvement in this respect.

The matter of lead has received much attention, particularly with link motion, but, as a matter of fact, the measured full gear lead is only used possibly for a few turns of the wheels in starting the engine, and when running notches are in use the lead is entirely different, the amount being dependent upon various conditions. As the running notch leads for best results are within narrow limits, it is apparent that the full gear leads vary within a wide range. The amount of full gear lead is therefore of little importance in the operation of the engine if the running notch lead is right. If these premises are correct, then there can be no argument as against the constant lead characteristics of the Walschaert motion, provided the lead is the proper amount for the running notches. The valve motion diagrams show that all the other events as derived by a link motion can be duplicated by the Walschaert motion so that, except in so far as the lead is concerned, equivalent operation can be obtained; hence, equivalent economies.

The practical operation of Walschaert motion is best shown by the testimony of roads using it in considerable numbers, and at a recent meeting of motive power officers and locomotive builders, held to discuss the results of the use of Walschaert motion engines, the roads represented having about 1,000 such engines, it was the unanimous opinion that Walschaert motion was equally well adapted to fast and slow passenger and freight service; that equivalent economies in fuel and water were obtained; that no reductions of tonnage ratings were necessary; that expense of maintenance and repairs were reduced; that inspection and repairs were facilitated; that construction advantages in the way of frame-cross bracing, etc., were increased; that valve adjustments made are maintained and engines kept square much longer on account of the motion being more direct, rigid and positive for the passage of the valve-driving stresses; and that convenience of the enginemen, inspectors and shop men is promoted by the accessibility of the motion.

The discussion thus far has been with reference to the valve actuating mechanism proper, as ordinarily used on locomotives for operating the usual types of slide or piston valves. There are available for the use of railroads some patented forms of valve motion or systems of steam distribution which are claimed to obtain economies superior to those of the types already mentioned.

The Young valve gear has been applied to engines with Stephenson link and later a Walschaert motion having some detail modifications from the regular design has been proposed. The motion acts upon a wrist plate which has connections to two semi-rotary valves, and the effect of the combination produces valve events remarkable on account of absence of pre-admission, small amount of lead, quick port opening, large exhaust area and fine equalization of the events. It is claimed, due to these features, that fine performance and superior economies are obtained which more than compensate for the cost of maintenance of additional parts required.

For the past six years, the Allfree-Hubbell designs for improving steam distribution have been under test and the designers have made changes from time to time. The first design or "geared system," as the designers called it, has been superseded by what is known as their "compression system," some of which have been in service for several months. This design is supposed to embrace the economic features of the original design with some additions, and, as it now stands, it attempts to produce the following results: late release, late compression, low clearance, balanced compression, reduced cylinder radiation, quick admission and quick release. In the later design an auxiliary valve has been introduced for the control of compression alone, and allows the main valves to be made and set for a desired release with the Stephenson link, Walschaert, or any other motion, all the changes being made in the cylinders and valve alone.

This device has been under test on several roads and from an average of several reports it seems to give about 6 per cent. reduction in fuel consumption and 5 or 6 per cent. increase in train load, and is able to maintain the same or a little more speed than engines of the same size and ordinary design, except the cylinders. There is also a lighter drain on the boiler for steam, but we are unable to express the amount in figures. In making a study of this system for causes of the results claimed, we find a very late compression, which, according to the argument of the designers, means that the negative working pressure is acting at a time when it produces the least effect on crank pin. In other words, when the crank pin is very near the center, from this point alone, an increased load is possible, not so much from an increased working pressure as from a reduced negative work. In view of the above argument any given load could be handled with a less amount of steam, which means a less amount of coal and therefore brings the handling of greater load within the possibilities of the boiler. In addition to this, the reduced clearance is claimed to be responsible for a considerable steam economy.

Locomotive Lubrication.

Committee—D. R. MacBain, R. D. Smith, R. F. Kilpatrick, C. Kyle, W. O. Thompson.

With reference to high steam pressure and superheated steam.

At the 1906 convention, your committee reported that for locomotives with steam pressures as high as 225 pounds, or those using superheated steam, the temperature of which is as high as 600° F., the ordinary valve oil had been found by experience to be quite suitable, and the problem is one of delivering the oil in proper quantities to the places needing it; your committee believes the latter is possible with the modern sight-feed lubricators now in use.

How far may we economize in lubrication, both internal and external?

Internal Lubrication.

Internal lubrication should not be stinted, for it is more important that an engine perform its work properly and without undue wear or heating. Dry valves and dry cylinders mean rapid wear of the surfaces of contact in the steam chest and cylinders, also excessive trouble with the valve motion parts. Too much economy in the use of oil for internal lubrication is apt to result in hot or slipped eccentrics, broken eccentrics, eccentric straps, links, transmission bars, rockers, valve stems, and connection pins, and aside from the increased machine friction, the performance of the engine is affected. Hard-running valves cause a derangement in steam distribution, and worn packing in valve chambers or at rods causes a loss due to leakage.

With the slide-valve locomotive there is not so much danger of these troubles, as the jar of the reverse lever attracts attention to the fact that oil is needed and the engineman will see that the valves are properly lubricated. With piston-valve locomotives the internal lubrication may be much below the required amount without any indication from the reverse lever, and the cause of the trouble may operate a long time before being discovered; in other words, the engineer on a slide-valve engine, even on a small allowance of oil, is more apt to keep the valves supplied with enough oil to prevent hard service to the machine, while with piston-valve engines he does not have this indication that the valves need oil, and no one knows that the parts have been running too dry until trouble comes through heated bearings and worn or broken parts.

Your committee feels that for internal lubrication, 70 miles per pint for large freight locomotives and 80 miles per pint for large passenger locomotives seems to be the amount needed to lubricate properly. The amount for each class depends upon the speed at which the locomotive is running; in bad water districts the oil allowance should be increased about 25 per cent.

External Lubrication.

The use of grease on crank pins and driving axles seems to offer the best solution of how to decrease the cost of external lubrication and at the same time secure the best results. The committee report of last year gave some experiences with 203 locomotives, showing that grease as a lubricant, gave results about as follows:

(a) Reduces engine failures due to heated journals and pins.
(b) Reduces cost of lubrication.
(c) Reduces cost of labor incident to inspection, cleaning and renewal of lubrication packing.
(d) Reduces delays incident to oiling.
(e) Reduces cut journals incident to oil lubrication.
(f) Possibly produces a slight increase in machine friction.

In reference to the cost of external lubrication as compared with that of, say, four years ago, your committee believes that the cost per square inch lubricated, or per pound carried, is less with the use of hard grease than when oil was in general use.

The consideration of sight-feed lubricators versus pumps for internal lubrication.

Your committee is of the opinion that a well-designed sight-feed lubricator, having pipe connections suitably arranged to deliver the oil in the most direct way to the parts needing it, will under present conditions do the work properly. On superheated locomotives it is, we believe, generally conceded that there should be one pipe from the lubricator leading direct to the cylinders and attached to separate plugs near the center, so that the oil fed from the lubricator for the cylinder may be properly distributed. The question of location of plugs in the steam chest is one point on which we find considerable difference of opinion; one member of your committee, who has had considerable experience with superheated steam, favors putting the steam chest plugs at the end of the valve chest in preference to attaching the oil pipe to the center of the chest and letting the oil be carried by the steam to the parts where needed; and your committee as a whole believes that the question of locating steam chest connections is one that can be left open, and, therefore, do not care to make any recommendations.

Subjects.

COMMITTEE REPORTS.

1. Laboratory test of the various valve gears in use—Stephenson, Walschaert, Alfree-Hubbell, and Young—at Purdue or Altoona, to determine their relative efficiency. R. D. Smith (Chairman), F. H. Clark, W. F. M. Goss.
2. Best system of washing out and refilling locomotive boilers, including blow-off lines, flushing tanks, hot wells, and other similar methods and data pertaining to benefits in the way of reducing defects in fire-box sheets, staybolts and tubes. H. T. Bentley (Chairman), L. H. Turner, W. R. McKeen.
3. Organization of large railroad shop forces. H. H. Vaughan (Chairman), James Milliken, W. H. Lewis, T. S. Lloyd, A. E. Manchester.
4. A system of accounting for labor and material for railway repair shops. H. Emerson (Chairman), T. H. Curtis, Le Grand Parish.
5. Handling scrap. H. D. Taylor (Chairman), D. J. Redding, A. Forsyth.
6. The use of castellated nuts for machinery of locomotives with a view of having some standard dimensions established. Committee to be appointed by the executive committee.

INDIVIDUAL PAPERS.

Is it desirable to have uniform specifications and drawings of locomotives covering the most common types and sizes? To be presented by Mr. G. M. Basford.

Standard definition of the term "engine failure," with a list of locomotive characteristics and the numerous varied conditions of operation on which any definition would need to be predicated, in order to enable comparison to be made. To be presented by Mr. M. K. Barnum.

Design and strength of crank axles for balanced compound locomotives. To be presented by Mr. F. J. Cole.

Committee—Henry Bartlett (Chairman); J. A. Carney, R. P. C. Sanderson.

(To be continued.)

MASTER CAR BUILDERS' ASSOCIATION.

Forty-first Annual Convention.

The convention was called to order on the Steel Pier, Atlantic City, June 17th, by Mr. W. E. Fowler, president. Mr. Fowler's address indicated a very careful and comprehensive study of the work before the Association and was enthusiastically received. He spoke of what had been accomplished in the past, reviewed the reports to be considered at the convention and made a number of valuable suggestions as to the future work of the Association. One of the most important of these may best be presented by quoting from the address as follows:

"Some of the railroads of this continent have, in times past, generously contributed not only the time of officials, but, in many cases, materials and equipment towards the advancement of committee research, and I believe that there will always be a spirit of this kind manifested by progressive railroads. But, the problems confronting the Master Car Builders' Association, which were in the past solved by the exercise of good judgment, by careful observation or by averaging the experience of all interested parties, must in the future, in my opinion, be supplemented by the precise methods of science, and materials which were unknown to our fathers, but which promise valuable assistance, must, in many cases, have their physical properties and chemical composition made known, before they can be used in practical railroading.

"Considerations such as these suggest to me the desirability of the organization by the Master Car Builders' Association, of an expert staff, which would be qualified by education and training to handle problems either mechanical, chemical or physical.

"Such an organization should have its home in a laboratory befitting the dignity of the great interests represented by this Association, such as would be possible at Purdue University, or a similar institution. Not only would the members of such a staff be able to give their undivided attention to the problems of this Association, but the sustained character of their efforts would make their work cumulative.

"Bringing to bear upon the problems with which they were confronted, minds trained for scientific research and habituated to the study of railroad problems, the work of such investigators should be invaluable. Operated under the direction of the executive committee of the Master Car Builders' Association, and sustained by all the railroads of the country, such a laboratory and staff, actually in co-operation with the working committees of this association, would return many times its cost to the railroads of the country.

"I am aware that this organization cannot be arranged for in a day, it must have a small and inconspicuous beginning, but, as that has been the history of this Association, I do not think that should deter us from entering, at an early date, upon a plan which will permit an early organization of a small staff of this kind, upon a permanent basis, and I would recommend that this convention request its executive committee to consider and act upon this idea, if it deems it advisable."

The members of the Association have come to look upon the address of Mr. E. A. Moseley, secretary of the Interstate Commerce Commission, as one of the most important features of the convention and because of the events of the past year it was looked forward to with even more eagerness than usual. He called attention to several developments which have recently taken place, spoke of complaints which had been received concerning the condition of the equipment and plainly stated the position which the Interstate Commerce Commission intended to take in regard to them. Of the various defects constituting the basis of prosecution, inoperative uncoupling mechanism constitutes a large majority, there being 672 cases of this character.

The secretary's report showed a total membership as follows: 336 active members, 249 representative members, 14 associate members, 15 life members; total, 614. The number of cars represented is 2,047,327, an increase of 207,070 over last year.

The treasurer's report showed a balance of $6,640.69.

Mr. John T. Chamberlain was elected an honorary member.

Revision of Standards and Recommended Practice.—The report of this committee was exceptionally complete and indicated much careful and painstaking investigation and study. In the absence of Mr. T. S. Lloyd, the chairman, the report was presented by Mr. C. A. Seley. A large number of the recommendations were referred to letter ballot, including slight changes in the 5 x 9 and 5½ x 10 journal boxes, the changing of the radius between the wheel seat and rough collar on axles, the specifications for brake beams, the adoption of a standard straight link handbrake chain, certain changes in the standard for the protection of trainmen, etc.

Arbitration Committee.—Part of the report referring to the placing of advertisements on cars was modified and the date for the final equipment of cars with standard air-brake hose was extended to September, 1908. The report including these modifications was accepted and adopted.

Triple Valve Tests.—The report was accepted and the committee continued.

Brake Shoe Tests.—The committee presented as an appendix to the report a very carefully prepared study and summary of the work of the brake shoe committee extending over the past 12 years. This was prepared by Mr. F. W. Sargent, of the American Brakeshoe & Foundry Company. Recommendations made by Mr. Sargent as indicated by the following extract from his paper were referred to the executive committee:

"The M. C. B. record of shoe tests, while most important and valuable, will remain incomplete until checked up by service tests. The brake-shoe testing machine records results under ideal conditions—a steady wheel moving true with a constant uniform braking load and perfect contact between shoe and wheel, with clear, dry surfaces in contact under practically uniform climatic conditions.

"In actual service we have the reverse, namely, an unsteady wheel pounding along over uneven track, more or less elasticity in brake beams and brake connections, and fluctuation in braking pressure, coupled with the varying contact between wheel and shoe with extremes of climatic conditions from cold to hot and wet to dry.

"The test wheel is uniform in its bearing against the shoe, and always moving in the same direction, the projections tend to bend away from the shoe and the surface of the wheel to polish up and to smooth over and afford a better contact than in the case of the wheel in service conditions. With the ordinary car wheel the unflanged brake shoe covers that part of the wheel not in contact with the rail, as well as that part of the wheel which is in contact with the rail; so that there are two distinct surfaces under the shoe. The side motion of the brake shoe is continually varying the amount of contact between the shoe and these two surfaces, while the inequalities of track condition and the pounding of the wheel cannot do otherwise than break the grip of the shoe on the wheel, all of which means that the actual coefficient of friction from the service tests is much less than that indicated in the shop test.

"To make the records complete, therefore, some connection should be made between shop and service tests, and to my mind this can be done without very much trouble and expense. The management of some of the electric roads in the West, in the vicinity of Purdue University would, I believe, be much interested in conducting a service test of brake shoes with a heavy electric car in interurban service, using unflanged M. C. B. Christie type of brake shoes on 33-inch wheels, and I believe a series of tests could be arranged using brake shoes previously tested on the M. C. B. machine, and after service stops had been made, returned to the machine for further test. It would not be necessary to test all the various types of brake shoes, but say three different kinds of shoes illustrating those in general use on locomotives, steel-tired coach wheels and chilled wheels."

The committee was also instructed to test the wearing as well as the frictional qualities of the shoes and to determine the relative wear on the wheel.

Tests of M. C. B. Couplers.—In the absence of the chairman the report of the committee on this subject was read by Mr. Kleine. It was announced that, although the name of Mr. T. H.

Curtis did not appear with the committee on the report, he fully concurred in its recommendations.

Mr. F. W. Brazier said that he believed the maintenance of the draft rigging and couplers was the most important feature in the car department work. The trouble along these lines was on the increase. One of the greatest difficulties he had found was the fact that repair parts were not always duplicates of the original, and hence did not fit properly. He considered that nothing but the best material should be used for knuckles and that great care should be given to seeing that they were exact duplicates in size with the original. It might be necessary to even go to the drop forged knuckle. Expense should not be considered in this connection.

Mr. R. P. C. Sanderson endorsed all that Mr. Brazier had said. He moved that the recommendations be submitted to the committee on standards and called attention to recommendations No. 1 and No. 10, with which he did not fully concur.

Mr. J. J. Hennessey questioned the judgment of having a 2½ in. movement between the horn of the coupler and the face plate. He also believed that the side movement recommended was excessive, and stated that while it would give relief to the end of the car it would throw greater stress on the flange of the wheel, which is the weakest part of the car structure.

Mr. C. A. Schroyer upheld Mr. Hennessey's remarks in connection with the longitudinal movement of the draw bar, especially in connection with broken links and clevises of the uncoupling apparatus. His road had been having a great deal of trouble with these parts being broken.

Mr. McIntosh took issue with Mr. Hennessey in regard to the side clearance, stating that he had been operating cars for two years with a greater clearance than that recommended, with entire satisfaction. He believed that it had had a favorable effect on the flanges of the wheels.

Mr. F. H. Stark disagreed with Mr. Hennessey in regard to the longitudinal movement of the coupler, stating that he believed that it should be even more than at present, because of the impossibility of stopping the momentum of the cars so suddenly, as the draft gear fails to absorb the shock in short movements and transfers it directly to the car frame.

Mr. E. A. Moseley drew attention to the fact that the elimination of broken chains and the attachment for lifting the pin would largely do away with further prosecution of railroads by the Interstate Commerce Commission. He urged the importance of finding some way of remedying this trouble.

Mr. T. H. Russum believed that the flange wear would be considerably helped by more lateral movement of the coupler. He also thought that some uncoupling attachment could be devised which would eliminate the use of the chain.

Mr. C. H. Schroyer moved the appointment of a committee on couplers relative to the use of an unlocking apparatus that will do away with chains, with the understanding that the device recommended should be applicable to every coupler on the market. This motion was carried.

Rules for Loading Long Material.—The report was presented by Mr. A. Kearney and, upon the motion of Mr. Sanderson, was accepted and referred to letter ballot.

Cast-Iron Wheels.—The report was read by Mr. William Garstang, who also presented a letter from Mr. Muhlfeld, a member of the committee, stating that he did not concur with the recommendations in several particulars, which particulars were stated and will be published in the proceedings. A letter from the car wheel manufacturers was also read, drawing attention to the fact that the increase in the thickness of the flange added about 15 lbs. to the weight of the wheels, and hence the weights as specified for 33-in. wheels should be increased by this amount, unless there was a decrease in section at some other point.

Mr. J. J. Tatum took exception to the committee's recommendations for the limit of flange wear, which was specified to be 1⅛ in. for 100,000-lb. capacity cars; 1 1/16 in. for 80,000-lb. cars, and 1 in. for 60,000-lb. cars. He believed that 1 in. should apply for both 60 000 and 80,000-lb. cars, and that 1 1/16 in. should be allowed on the 100,000-lb. cars. He stated that in his experience the greater number of broken flanges were practically full size flanges, indicating that the limit wear is not going to help matters materially as far as broken flanges are concerned, and that the increase of 1/16 of an inch would allow a much increased mileage.

Mr. R. L. Kleine stated that his experience was that from 50 to 60 per cent. of the total number of flange breakages on 100,000-lb. capacity cars were below the 1⅛-in. limit, and that a limit placed at that figure would save that many broken flanges, and hence was of vital importance. He recommended that the gauge shown in the committee's report for flange wear should have the radius at the fillet or throat of the wheel at 3/16 in., the present standard, instead of ⅜ in., as recommended.

Mr. A. W. Gibbs stated that the Pennsylvania Railroad had in the year 1904 voluntarily increased the limit of flange wear to 1⅛ in. with a most decided improvement. This improvement, however, might partially be attributed to the coned tread which was adopted in 1903. He believed that flanges broke not because they were thin, but because there had been so much peening action by the rail, tending to wedge the flange of the wheel. The amount of wear was a direct measure of the amount of this peening.

Mr. F. F. Gaines stated that while probably 90 per cent. of the broken flanges on his road were full flanges, yet he agreed with the committee's report in respect to the stronger standard at that point, as one broken flange which had worn too thin, causing a wreck, would more than pay for the decreased mileage of the rest of the wheels.

The question of the increase of the size of the fillet in the throat above 11/16 in. was taken up and several members stated that they had obtained considerable improvement by an increase in the radius at this point. The subject was finally disposed of by a motion that the committee be instructed to change its recommendations to include a symbol designating the new wheel and that the words "normal diameter" in paragraph 4 be stricken out. The recommendations as thus changed will be submitted to letter ballot.

Arch Bars for 80,000-Lb. Capacity Cars.—The report was read by Mr. C. A. Seley, received and referred to letter ballot.

Air Brake Hose Specifications.—The report of this committee was read by Mr. Parish and the committee was continued.

Chemical Analysis of Air-Brake Hose.—The report was read by the secretary and accepted, and the committee was continued.

High-Speed Brakes.—The report of this committee was read by Mr. F. M. Gilbert, received and referred to letter ballot.

Height of Brake Staff.—The report of the committee was read by the secretary.

Mr. C. A. Seley moved that the report be received with the exception of that portion relating to the distance of the staff from the center of the car, which is already covered in the standards for the protection of the trainmen, and that it be referred to letter ballot. This motion was finally carried.

In the discussion of the motion Mr. C. A. Schroyer called attention to the height of the standard cars recommended by the American Railway Association and urged that the members give particular attention to the recommendations of this committee when voting by letter ballot.

Mr. R. P. C. Sanderson stated that he did not believe the height of the car had anything to do with it, but that the committee's recommendations were such as to allow the cars to pass freely in interchange, and that the governing feature was the clearance on important railways. In this connection Mr. Trimyer stated that the clearance line of the N. Y. N. H. & H. R. R. is 14 ft. 3½ in. from the top of the rail.

Automatic Connectors.—The committee on this subject reported as holding no meeting during the year, hence no report was submitted and no action was taken.

Tank Cars.—The report of this committee was read by Mr. C. M. Bloxham, who called the attention of the members to the reasons for the changes as recommended in the report. He also supplemented the report by a discussion of the advisability of

omitting the stenciling of the tare weight and capacity weight on the car and recommended that Rule 23 be revised by the insertion of the words "except tank cars." The subject of stenciling the cars was thoroughly discussed from both sides, and was finally disposed of by a motion that the recommendations of the committee be accepted and referred to letter ballot, except the part referring to the stenciling, which should be submitted to letter ballot under a separate heading.

Stresses to Which Wheels for 10,000-lb. Capacity Cars Are Subjected.—The chairman of the committee, Mr. J. F. Walsh, reported that the committee had found the subject so difficult as to be beyond its powers and advised that it be turned over to some specialists who are equipped with apparatus for making tests. He reported that Mr. George L. Fowler was preparing to make some experiments along these lines.

Mr. Fowler gave a brief outline of the nature of the apparatus he had designed and stated that he hoped by next year to have some interesting figures at hand.

It was moved and carried that the committee be discharged, and that Mr. Fowler be requested to present an individual paper on the subject at the next meeting.

Clearance of Electrical Equipment.—A letter from Mr. Deems was read by the secretary, which stated that the matter was now in the hands of a committee of the American Railway Association, which included practically the members of the M. C. B. committee, and that no report would be made by that committee at this time.

Subjects.—The report of the committee was accepted and referred to the executive committee.

Election of Officers.—The election of officers for the coming year resulted as follows:

President—G. N. Dow, General Mech. Insp., L. S. & M. S. Ry., Cleveland, O.

First Vice-President—R. F. McKenna, M. C. B., D. L. & W. Ry., Scranton, Pa.

Second Vice-President—R. W. Burnett, A. M. C. B., Can. Pac. Ry., Montreal, Can.

Third Vice-President—T. M. Ramsdell, M. C. B., C. & O. Ry., Richmond, Va.

Members of the Executive Committee—D. F. Crawford (P. R. R.), T. H. Curtis (L. & N. Ry.), and F. H. Clark (C. B. & Q. Ry.)

TOPICAL DISCUSSIONS.

Lateral Coupler Clearance.—This subject was opened by Mr. Parish, who stated that the large amount of trouble with flange wear and breakage on his road had led them to try experiments with greater side clearance on the couplers. They had tried a clearance of 4 in. in place of the standard 2½ in. for two years with excellent results. The wheel flanges showed but little wear, and the general condition of the cars was good. He advocated the appointment of a committee to thoroughly investigate the subject and report next year.

Mr. Hennessey did not agree with Mr. Parish on this point, believing that greater coupler clearance would throw greater stress on the wheel flanges.

Mr. Gaines suggested that if a committee was appointed it should also investigate the desirability of a centering device in connection with increased clearance.

Mr. J. J. Tatum believed that all strains should be removed from a car as far as possible. If the coupler binds it should be given more clearance.

Mr. DeVoy stated that the experiments he had conducted indicated that an increase of coupler clearance over the present limit would result in increased flange breakage.

Mr. Brazier reported good results with the increased clearance. He hardly considered a centering device necessary, as with the wide yoke strap and a draft gear with initial compression, the coupler centered itself very nicely.

Mr. J. J. Tatum reported some tests he had made on sharp curves which indicated the desirability of more clearance in some cases.

Mr. Seley drew attention to the matter of overhang and wheel base having an effect on the coupler clearance.

Mr. W. F. Kiesel stated that the tests he had made indicated the desirability of more side clearance for couplers.

Mr. Fuller called attention to the difference between steel and wooden cars in the matter of requiring greater clearance. The wooden cars were not giving any trouble, but he had found it necessary to consider the matter very carefully on steel cars.

Other members spoke, usually in favor of greater clearances.

Truck Springs on Journal Boxes Rather Than Under the Bolster.—This subject was opened by Mr. F. W. Brazier, who stated that in his opinion the best arrangement of the springs in a truck was that which would most effectually cushion all moving parts. Thus by placing the springs on the journal box the non-spring supported parts were reduced to a minimum and the result will be a much longer life to the truck itself and less damage to tracks and bridges. The weight of the non-spring supported part of an arch bar truck having 5½ x 10 in. axles is about 11,000 lbs. This could be reduced to 5,200 lbs. by placing the springs over the boxes. He reported that his company had over 30,000 cars equipped with trucks having springs over the boxes and also over 1,000 tender trucks of the same design, all of which had given excellent service.

He further stated that while he did not wish to be considered as defending the Fox type of truck, he would say that they had less trouble with that truck than any other type, and also that less than 1 per cent. of the derailments were with this type of truck. In reply to a question he stated that he had not noticed any difference in the wear on the journals between the Fox truck and the arch bar truck.

Solid Steel Wheels for Passenger Service.—The discussion of this subject consisted of a detailed account of a series of tests which had been made and were reported by Mr. George L. Fowler. He had gone into the physical and chemical qualities of the material in the solid steel wheels very carefully and also experimented with the wearing qualities in actual service. The conclusions that he reached from these experiments were that the metal in the solid steel wheel is fully equal to that of the ordinary steel tire and that in other respects the solid steel wheel was equal in every way to the steel tired wheels and that it simply remains a question of price and value of scrap to decide which wheel to use in passenger service.

Up-to-Date Cleaning of Passenger Equipment.—Mr. P. H. Peck opened the discussion by giving a description of the coach cleaning yard, equipment and methods used on the Chicago & Western Indiana Railroad, where from 6,000 to 7,000 cars per month are cleaned. This included the cost of cleaning the different cars which gave an average for nearly 90,000 cars of 77.8 cents.

Mr. McIntosh reported that the vacuum system of car cleaning in use on his road had been so satisfactory that they now considered it almost indispensable.

Mr. Brazier stated that in the new yards which were being installed on his road both the exhaust and straight air systems were being used. He drew attention to the fact that there was a great diversity in the application of the term "car cleaning," which might mean almost anything from a walk through the car to a thorough scrubbing.

Mr. B. Julian stated that he believed that the vacuum system was the best for cleaning cars. He considered it cheaper than straight air when all things are considered.

Other members described various systems in use on other roads and there was a very general desire for information as to the cost of cleaning by the vacuum system as compared with straight air.

Passenger Car Ventilation.—The discussion of this subject was opened by Mr. McIntosh, who covered the requirements of satisfactory ventilation in a somewhat extended manner and pointed out the limitations of most of the ordinary schemes. The chief of these is the fact that ventilation depending upon the moving train ceases when the car stops. He thought it quite possible that some scheme might yet be evolved which would be operated by a system of independent motors and would furnish constant and controllable ventilation which would be perfectly satisfactory.

Mr. Schroyer described the ventilators in use on the C. & N. W., consisting of a jack located in the roof of the car, being continued inside by a tube which conducts the air over the radiator and discharges it into the body of the car at the floor level. He had examined many ventilating devices, but as yet had found nothing that answered the purpose as well as this device.

Mr. R. L. Kleine discussed the system in use on the Pennsylvania, which was evolved by Dr. Dudley a number of years ago.

Abstracts of Committee Reports.

Brake Shoe Tests.

Committee—W. F. M. Goss, G. W. West, B. D. Lockwood.

The results of tests made on a shoe submitted by the C. C. C. & St. L. R. R. were presented.

In its report to the 1906 convention the committee called attention to the fact that up to that time the activities of the committee on brake shoes had been confined to a study of frictional qualities, and the importance of some work being undertaken which might lead to information concerning wearing qualities was urged. The practicability of such tests was shown, and a design for a proposed addition to the testing machine which would make them possible was presented as an appendix to the committee's report.

From a study of the problem the committee reached the conclusion that tests to determine the durability of the shoe might readily be made in the laboratory, provided some additional mechanism could be attached to the brake-shoe testing machine. The purpose of the proposed addition would be to permit the shoe to be brought in contact with the wheel of the testing machine for a predetermined interval, after which it would be automatically released, remaining in release position for another and a much longer interval, during which time both wheel and shoe would return to their normal temperature. It was believed that by such a cycle any shoe could be given a definite amount of exposure to wear, that a comparatively short interval during the application and a much longer one during the release would avoid all chances of excessive heating, and that by its automatic action the motion of the machine could continue hour after hour, with but little attention from the laboratory attendants. Accessory to the large machine there would of course be required a registering counter to show the number of applications, and a delicate balance for weighing the shoes before and after they are exposed to the action of the machine.

A mechanism which, when applied to the existing testing machine, would give the function above described, had been designed under the direction of a member of your committee, by Mr. Fritz Ernst. Mr. Ernst being no longer available for the work of your committee, the whole problem of design and construction was generously undertaken by Prof. W. P. Turner, of the department of practical mechanics of Purdue University. As a result of his study it seemed best to abandon entirely the lines previously laid down and to employ compressed air for bringing about the required movements, the supply and discharge being governed by a light and comparatively inexpensive valve driven by gear connections with the testing-machine shaft. A detailed description of the added equipment as designed by Professor Turner and constructed under his direction is given in the appendix. It need only be said here that under the control of the apparatus the brake-shoe testing machine may be run steadily at any given speed, the shoe being automatically applied and released. The apparatus was placed in service early in April and has since been employed in tests. Two sets of connecting gears are at present supplied. By the use of one, hereafter referred to as Gear A, the shoe is in contact with the wheel approximately 1-10 of the total time and by use of the other, hereafter referred to as Gear B, 1/4 of the total time. The exact action is as follows:

The Cycle as Controlled by Gear A.

Revolutions during which shoe is in contact with wheel......	160
Revolutions during which shoe is out of contact with wheel..	1,440

Under the control of this gear 1,600 revolutions, or approximately the equivalent of 2.6 miles running, were required for each complete cycle. After some preliminary running it was decided that progress under this cycle was unnecessarily slow.

The Cycle as Controlled by Gear B.

Revolutions during which shoe is in contact with wheel......	190
Revolutions during which shoe is out of contact with wheel..	610

Under the control of this gear 800 revolutions, or approximately the equivalent of 1.3 miles running, were required for each complete cycle. It was found that by employing a speed equivalent to twenty miles an hour and a brake-shoe pressure during application of 2,808 pounds, the machine could be kept in continuous motion under the cycle without undue heating either of the wheel or shoe. The severity of test conditions may be judged by the fact that the work done by the brake shoe during each application is approximately the same as that which would be done by each of the eight shoes of a loaded 100,000-pound capacity car in bringing the car to rest on a level track from a speed of forty miles an hour. Shoes giving a high coefficient of friction, however, are under test conditions exposed to action which is somewhat more severe than that which would be required to stop the car. Under these conditions the wheel never became more than sensibly warm to the touch, and the shoe never excessively hot.

Shoes subjected to wearing test.—In selecting shoes for test, it was thought proper to take those for which frictional results were reported last year. Fifteen such shoes were available. All had been submitted for test by railway companies, and had been taken from service after having been about half worn.

The tests to determine resistance to wear.—The cycle employed was that obtained by use of Gear B and the conditions were those mentioned in connection with a description of that cycle. Briefly stated they are as follows:

Diameter of test wheel, inches..............................	33
Material of test wheel.................................	Cast iron
Revolutions per cycle	800
Revolutions during which shoe has contact with wheel.......	190
Revolutions during which shoe is out of contact with wheel..	610
Brake shoe pressure, pounds................................	2,808
Revolutions per minute	204
Equivalent speed in miles per hour.........................	20

By the maintenance of these conditions it was found easily possible to secure from eighty to a hundred applications in a single day's run.

In anticipation of a test, the shoe was carefully weighed on an accurate balance. It was then exposed to wear in accord with the program already set forth. A registering counter attached to the machine gave a record of the number of contacts. Weighings of the shoe made at intervals as the work proceeded, clearly showed that the loss of weight was always proportional to the number of stops. While the balance used in weighing the shoes was so delicate as to permit a determination of the loss for a single application, the values reported have in all cases been determined from a considerable number of applications for which the gross loss in weight was so great as to admit of no considerable error in determining its value. The results are given in columns one to eight of Table I.

A basis for comparison.—It is apparent that no measurement of wear is complete which does not take into account the frictional qualities of the shoe; that a true measure must include both wearing and frictional qualities and this is best expressed in terms of energy absorbed per unit of weight of material lost. Assuming that the conditions affecting the exposure of the shoe to wear are equally fair to all shoes tested, comparisons upon

TABLE I

WEAR OF BRAKE SHOES ON CAST IRON WHEELS

SPEED CONSTANT AT 20 MILES PER HOUR. PRESSURE OF SHOE ON WHEEL 2808 POUNDS REVOLUTIONS OF WHEEL DURING APPLICATION 190. EQUIVALENT DISTANCE RUN DURING APPLICATION 1641.5 FEET.

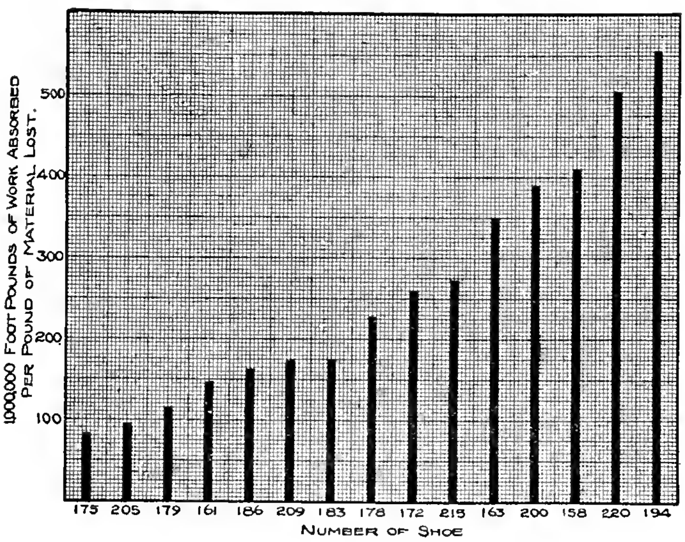
NUMBER OF SHOE.	RAILWAY CO SUBMITTING SHOE	MARKINGS ON SHOE	COEFFICIENT OF FRICTION	WEIGHT OF SHOE, POUNDS.	NUMBER OF APPLICATIONS	TOTAL LOSS OF WEIGHT POUNDS	LOSS OF WEIGHT PER APPLICATION POUNDS	1,000,000 FOOT-POUNDS OF WORK ABSORBED PER APPLICATION	1,000,000 FOOT-POUNDS OF WORK ABSORBED PER POUND OF MATERIAL LOST
1	2	3	4	5	6	7	8	9	10
158	HOCKING VALLEY RR	S IF STREETER	22.5	22.046	90	.229	.002544	1.036	407.2
161	"		21.8	21.208	94	.644	.006850	1.004	146.6
163	AT & SF RR	BXU 36 PAT FF 20 1900	21.7	19.964	118	.337	.002856	1.000	350.1
172	AT & SF R.R	G 79-B	22.8	17.180	90	.366	.004066	1.050	258.2
175	W & LE RR	MBC STD 33	30.3	11.202	40	.690	.017250	1.395	80.8
178	"	33 IN PAT 1 5 04	20.0	18.662	90	.364	.004044	.921	227.7
179	"	PITTSBURG BR SHOE CO	36.8	9.298	40	.593	.014825	1.695	114.3
183	D M & N RR		38.7	7.846	60	.615	.010250	1.782	173.8
186	"	C-23	24.1	13.778	90	.615	.006833	1.110	162.5
194	LSMS RR	LAPPIN	26.5	22.730	90	.198	.002200	1.220	554.6
200	"	STREETER	22.7	15.780	90	.243	.002700	1.045	387.0
205	"	STEEL BACK LSEMS CARS	23.5	17.610	90	1.058	.011755	1.082	92.0
209	"	STEEL BACK FULL CARS	24.7	16.818	90	.593	.006588	1.137	172.0
215	DSS & A RR		20.9	16.354	90	.320	.003555	.963	270.9
220	C & A RR	AM C & F CO.	26.5	13.066	91	.220	.002417	1.220	504.7

NOTE.

Shoe No. 194 under markings on shoe should read.......C. & N.-W. 8386.
Shoe No. 205 under markings on shoe should read.......P. C. P G 3960 Pat 4-11-93.
Shoe No. 209 under markings on shoe should read.......M. C. B. triangle enclosing U, U G-36 G.
Shoe No. 215 under markings on shoe should read.......4—83.
Shoe No. 220 under markings on shoe should read...... F 38.

this basis should constitute a satisfactory measure by which to determine the relative value of the different shoes as a means of stopping trains. Such a comparison is presented in column 10 of Table I, and is graphically shown by the accompanying diagram. A more detailed explanation of Table I is as follows:

Column 4 gives the coefficient of friction as reported to the convention of 1906. Column 5 is the weight of the shoe at the beginning of the wearing test. Column 6 shows the number of applications made. Column 7 gives the total loss of weight in pounds. Column 8 gives the loss of weight per application. This equals the total loss of weight divided by the number of applications. Column 9 shows the number of million foot-pounds absorbed per application. This is found by multiplying the pressure contact (2,208 pounds) by the coefficient of friction (column 4), by the distance in feet passed over by the surface of the wheel during the application (1,640), and by dividing by one million. Column 10 shows the million foot-pounds of work which can be done by each shoe under conditions of test for each pound of material lost. It is obtained by dividing the values of column 9 by those



of column 8. That the values in column 10 vary between wide limits is best shown by the diagram accompanying.

As to the significance of results.—In carrying out the tests all shoes were subjected to the same exposure to wear. Whether the relative results would be the same had the conditions of test involved lighter pressure or higher speeds than those which were actually employed, is a question which the committee has not yet had time to determine. It is not impossible that a shoe giving a relatively poor performance under the conditions of the test would show relatively better under some other conditions. If, for example, shoes are designed for specified service, it would perhaps be unfair to expect all to show at their best under a single condition of operation. The probability is, however, that a shoe which is good under one condition of running will not be bad under other conditions. But, as has been stated, these are questions which have not been studied, and the results as set forth in the accompanying diagram should be accepted, not as an absolute measure of the relative values of the shoes in question, but rather as an exhibit of facts obtained by a process which is clearly described and the significance of which each member will be able to judge for himself.

A Missing Factor.—It is a matter of regret that no measure has yet been made which will disclose the wear of the wheel under the influence of the shoe. To secure such a measure, it will be necessary to have a balance of sufficient capacity to weigh the wheel and of such delicacy as to indicate differences in weight as small as one five-hundredth part of a pound. No such balance is now available at the laboratory. The possibility that some of those shoes which show high performance in the accompanying diagram may have been protected from wear at the expense of the wheel makes it highly desirable that precise information be had.

Future Plans.—The preceding statements show the possibility of formulating a prescribed laboratory test covering the wearing qualities of shoes. Enough has been accomplished to reveal both the intricacies and the value of a much more elaborate study of the brake-shoe problem. It would seem that the time has come when mechanical tests could very profitably be supplemented by chemical analyses of the shoes tested, to the end that, step by step, the problem may be proven. Thus far the committee has not involved the Association in any considerable expense. It would be well if, in further expression of its interest, the Association could provide a fund sufficiently large to permit the committee to proceed actively for a considerable period along both mechanical and chemical lines.

The committee acknowledges its indebtedness to Mr. L. E. Endsley, instructor in the locomotive laboratory of Purdue University, for assistance rendered in the operation of the brake-shoe testing machine.

Tank Cars.

Committee:—A. W. Gibbs (Chairman), C. M. Bloxham, Robert Gunn.

It has developed that confusion exists at interchange points in regard to the phase of the specifications which covers construction "as strong as"; and it has actually developed that the same car might be accepted by inspectors on one part of a system and held up by inspectors on the same system at another point. This has entailed much vexatious delay and a very considerable amount of correspondence. In consequence, a meeting was held of representatives of a number of railroads handling a large number of tank cars, and the points causing confusion were discussed and amendments suggested in the wording of the requirements.

It is but fair to the committee to state that when the necessity for some regulation in regard to tank cars first arose, the construction of this class of equipment was, in general, stereotyped and bad, although there were certain ownerships whose cars were a notable exception. The committee recommended a standard which should be considered as a minimum requirement, but which has evidently been understood by many owners to be an expression by the committee of what is good enough. In the meantime, the severity of the service to which all classes of equipment are subjected has undoubtedly changed for the worse, and while the committee is not yet prepared to withdraw the earlier drawings covering minimum requirements for tank-car construction, it feels very strongly that it is to the interest, not only of the transportation companies, but, also, of the car owners as well, to very materially exceed the requirements for strength.

The committee suggested a number of changes in the specifications to make them clearer and more effective.

Air Brake Hose Specifications.

Committee—Le Grand Parish (Chairman), Jas. Milliken, F. A. Torrey.

The committee on air brake hose specifications wishes to call the attention of the association to an error in the specifications for air brake hose, as submitted to the association last year, and recommends that the following correction be made:

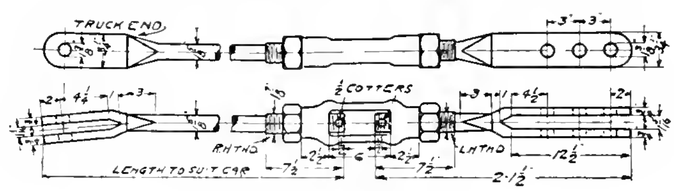
It will be seen that the label on the hose and M. C. B. Sheet No. 9 give the diameter of the hose as $1\frac{1}{4}$ inches, while in the detail of the specification the minimum diameter of the hose is shown to be $1\frac{3}{8}$ inches; therefore, the label and the cut on M. C. B. Sheet No. 9 should be changed to $1\frac{3}{8}$ inches.

The committee does not feel that any change should be made in the present specifications for the reason that last year it recommended that a chemical test be added to the specifications, and as a special committee is at work on this, we feel that no change should be made until this committee shall have completed its investigations and its report has been accepted.

High Speed Brakes.

Committee—F. M. Gilbert, chairman; S. G. Thomson, C. B. Young.

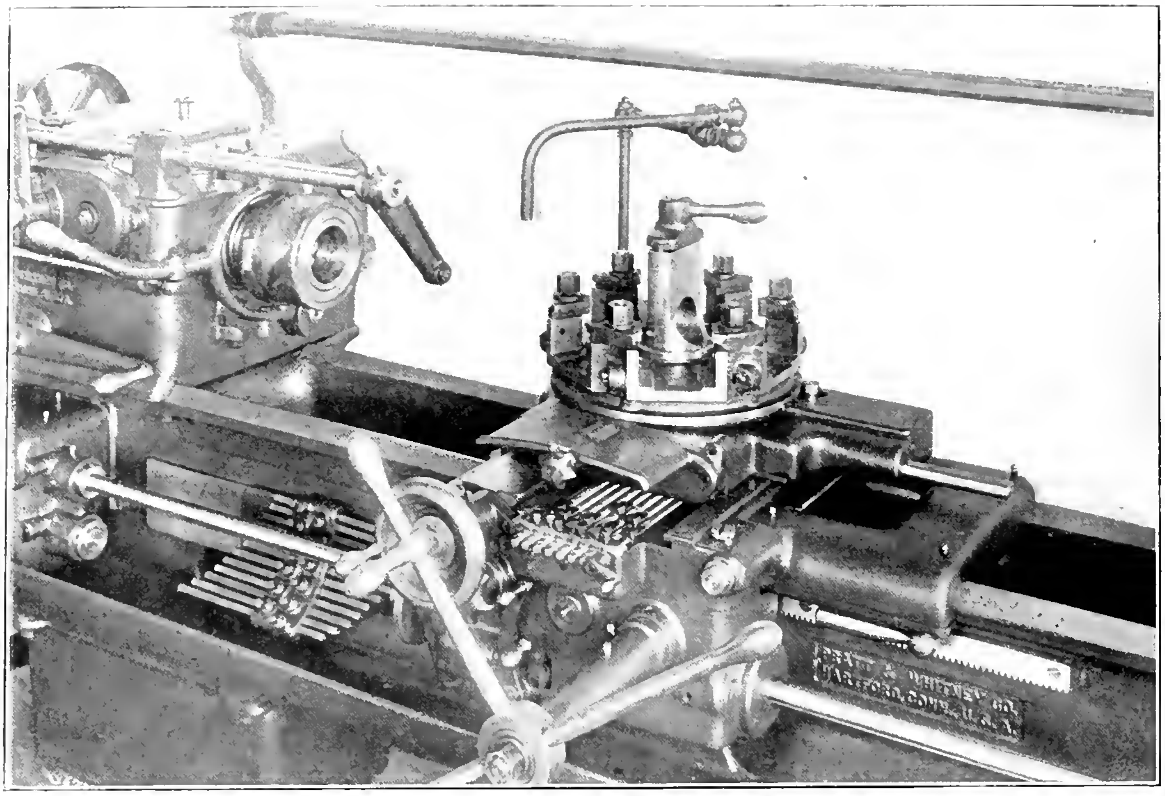
Provide for taking up the slack on six-wheel trucks, which accumulates from brake shoe wear, by substituting adjustable connection shown by attached sketch; substituting this connection for the one described on M. C. B. Sheet J as B-C7-A. The proposed connection has been tried out in service and found satisfactory.



The committee also suggests the addition to the different schedules of notes giving more prominence to the maximum theoretical load which may come on beams.

(To be continued.)

Extra Work Department of the Baldwin Locomotive Works.—The annual amount of duplicate parts supplied in recent years is the equivalent of about 100 new locomotives. In 1906, 368 pairs of cylinders were ordered and 80 boilers. In 1905, 196 locomotives were overhauled and put in first-class working condition.—*Arthur L. Church in "Record of Recent Construction," No. 60.*



OPEN TURRET LATHE—PRATT & WHITNEY.

2½ X 26 INCH OPEN TURRET LATHE.

The new Pratt & Whitney 2½ x 26-inch open turret lathe shown in the illustration is a universal machine suitable for doing a large variety of work from the bar and on forgings and castings, without continually requiring special appliances and expensive cutting tools. To accomplish this purpose, many new features, including a cross sliding turret, have been introduced. The machine possesses practically all the flexibility and adaptability of the engine lathe. The extreme rigidity, powerful spindle drive, quick changes of speeds and feeds, heavy cross feeding turret and numerous adjustable stops, admit of narrower limits of error, as well as a marked reduction in the cost, over work produced on the ordinary turret or engine lathe.

It has a stiff head, and may be driven either by a direct-connected motor or a countershaft drive by means of a single pulley. The turret is mounted on a slide, having both positive power and hand-longitudinal and traverse directions. The machine is recommended for bar work up to 2½ in. diameter x 26 in. long, for castings up to 14 in. diameter, and for cylindrical operations on work within these limits.

An unusually heavy spindle of special steel, with cylindrical bearings, runs in bronze split sleeves. The thrust of the spindle is against an independent upright, cast solid with the head, and insures against any springing tendency under heavy end cutting strains. Provision is made for taking up wear of the spindle and end thrust. The direction and speed of the spindle are controlled by levers operating friction clutches. It is impossible to connect more than one set of gears with the spindle and the main driving shaft at the same time. The gears are of extra heavy pitch and of ample width to withstand safely the hardest usage. The head, which is stationary, is of box construction, the gears running continually in oil. Eight variations of speed are provided, and by using a two-speed countershaft this may be doubled. All of the controlling levers and connections are within easy reach of the operator. The spindle can be instantly stopped by the movement of any lever on the head stock.

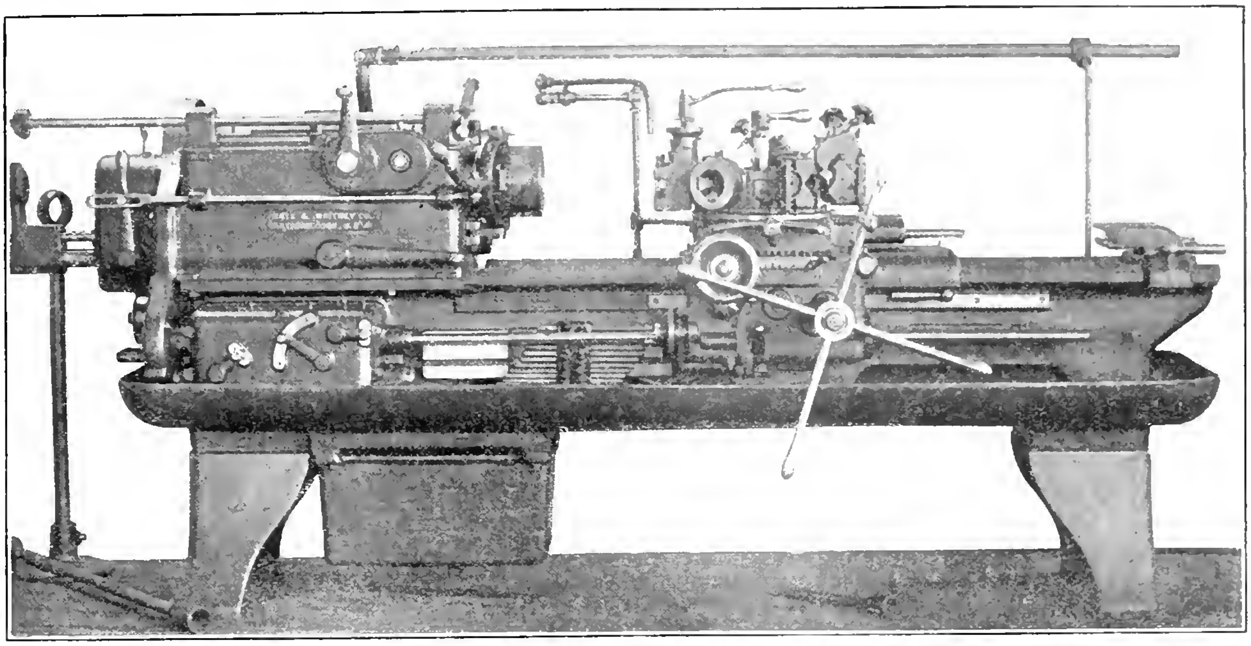
The rod chuck may be operated while the machine is running, and has extraordinary gripping power. The collet jaws are supported up to their outer end, which is especially desirable in forming work from the cross slide. The complete chuck can be removed readily from the spindle when combination lathe chucks or special face plates for castings are to be substituted. A positive screw feeding device automatically feeds the rod forward to its stop.

The bar may be round, square, hexagon, or of any irregular cross section, and need not necessarily be free from scale, as there are no delicate parts or complicated gearing to become clogged. A follower bar is furnished which enables short pieces of stock to be as conveniently handled as long bars, and at the same time serves to keep such pieces concentric with the spindle. An efficient stock stop for gauging the length of stock is provided, which, when not in use, is moved forward and swung upward, so as not to interfere with the turret tools.

The turret revolves about a large conical stud held firmly in the cross slide. The various tools may be accurately located and with rigid backing, so that the heaviest cuts may be taken without the slightest spring or backward movement. The tools are held in place by straps and are backed up by uprights cast solid with the turret. Severe tests have proven this to be a superior method of unyieldingly holding the tools against all torsional and backward strains. The locking-bolt is directly under the cutting tool and is horizontal, thereby overcoming the tendency of a vertical bolt to lift the turret from its seat.

Indexing can be accomplished at all positions of the cross-slide, and is automatic, although the turret may be rotated to any position by hand. One of the most important features in this lathe is the compound turret with power and hand feeds and adjustable stops which are conveniently located. The longitudinal turret slide travels on large raised "V's," is provided with gibs its full length, and a binder which permits the slide to be firmly clamped to the bed at any point within its travel. The power longitudinal feed is positive in both directions, and has six changes, any one of which can be set instantly.

There are six automatic longitudinal stops and six supplementary stops, which give two positions to each turret tool. If necessary, all twelve stops may be used for one or all tools in the turret, making it possible to effectively cover all requirements. The stops are held in a heavy steel bracket, which may be moved along the front of the bed and clamped where desired. In case it is desired to run through a few special pieces of work, the automatic stops may be dispensed with and the supplementary stops used in their place without the necessity of disturbing adjustments.



PRATT & WHITNEY 2½ x 26 INCH OPEN TURRET LATHE.

The distance from the axis of the spindle to the turret tool is altered by traversing the turret slide. This arrangement permits ample support for long bars, and if the machine is belt driven, gives an unvarying belt tension. A motor can be mounted on the head without difficulty. The cross slide has both hand and power feed. There are six variations of the power feed in either direction. Eight distinct adjustable cross stops are provided, which may be used in any combination desired.

The bed and pan are made in one single casting and have "U"-shaped cross webbing insuring rigidity. Generous provision for oil and chips is provided. A variety of turret tools adapted to meet practically all the various requirements are furnished to order.

AN IMPROVED TOOL POST FOR SLOTTERS.

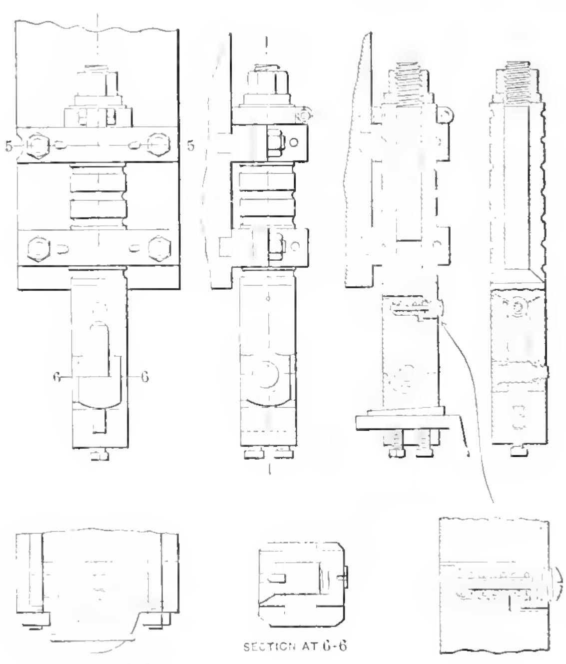
The tool post, shown in the illustration, is adapted for use on such machine tools as slotters, planers and shapers. It has a self-contained relief mechanism, so designed that high-speed tool steels may be operated to the limit of their cutting capacity. The illustrations show the tool post applied to a slotter. It is of simple and substantial construction; easy of adjustment; works equally well on long or short strokes, in corners, keyways, deep recesses, on plane surfaces and circles, and with the tool extended in any direction from 0 to 360 degrees about the vertical axis in a horizontal plane or with the feed coming in at any time or place.

It is so graduated that the work may be adjusted from it without having to move the carriage, thus saving considerable time and labor, especially on large parts such as locomotive frames. When large or irregular pieces are placed on the machine the post is simply slipped up out of the way and can easily be dropped back when the work is in place.

The construction is clearly shown on the drawings. The upper part or sleeve is clamped to the ram of the machine. Annular grooves are cut on this sleeve at intervals and by means of pins which pass through the clamping brackets the sleeve can be locked in place, insuring it against the possibility of being forced upward under heavy duty. The several annular grooves on the sleeve permit it to be closely adjusted to suit the work. By loosening the clamping bolts the sleeve can be adjusted about its own axis. The clamping collar at the top prevents the tool from dropping in case the clamps are loosened and the pins removed at the same time.

The upper part of the post has a forked lower end and a stem which passes through the sleeve and is held in place by the nut and washer at the upper end. The joint between this piece and the sleeve at the lower end is such that when the nut at the top is tightly drawn up any tendency toward lateral movement due to a loose fit between the sleeve and the stem is prevented. When the nut is loose the post may be swiveled to any position. These two parts have gauge marks upon them so that they may be brought to any predetermined position. One of the marks on the sleeve extends up to the clamping bracket upon which there is a corresponding mark and when these register the work on the table can be squared up and put in proper position by it, as a portion of the post at its lower end is squared for this purpoce. Pieces can thus be adjusted with less work than if adjusted from the table.

The lower part of the post is pivoted to the forked end of the



TOOL POST FOR SLOTTERS.

upper part, as shown. The lower part can swing backward slightly on the return stroke, the spring forcing it into place as soon as the tool escapes from the work. The tension of the spring may be adjusted to suit conditions by means of the screw and, if desired, the post may be made rigid by screwing it tightly against the shoulder of the lower member. The pivot upon which the lower part swings is placed to one side of the center

so that the faces of the two parts which come in contact when the tool in cutting will be of ample area.

The cutting tool is held in place by the tapered key and also, if desired, by the two set screws. This tool post has been in service at the Brightwood shops of the Big Four Railroad at Indianapolis, Ind., for about a year with very successful results and was designed and has been patented by Mr. William T. Slider, of Indianapolis.

4-CYLINDER DEGLEHN COMPOUND 10-WHEEL LOCOMOTIVE.

Paris-Orleans Railway.

The Baldwin Locomotive Works has recently built twenty 10-wheel locomotives for the Paris-Orleans Railway of France from drawings furnished by the railway company. The drawings had all of the dimensions given in the metric system and the work was performed in the shop from those dimensions, necessitating the introduction of many new standards and gauges and the training of the workmen in handling the new system.

These locomotives, as far as the cylinders, valve motion and the general features of construction are concerned, are practically identical with the DeGlehn compound purchased by the Pennsylvania Railroad in 1904, which was very completely illustrated and described in this journal June, 1904, page 203, and reference should be made to that description and accompanying complete drawings for the arrangement of this type of locomotive.

In brief, these locomotives are of the 4-cylinder balanced compound type, with the outside high pressure cylinders connecting to the second set of drivers and the inside low pressure cylinders connecting to the cranked axle of the forward drivers. The cylinders have independent valve gears, both of the Walschaert type, the outer one being driven by the return crank and the inner one from eccentrics. The low pressure cylinders are set directly below the saddle, which forms part of the same casting, while the high pressure cylinders are set some distance back of this. The high pressure valves are of the balanced slide type, being constructed of bronze, while the valves of the low pressure cylinders are non-balanced, also of bronze. They have inclined seats and their steam chests are formed within the cylinder casting. The cylinders are set on an inclination of 3½ per cent. Steam is conveyed to the high pressure cylinders through outside steampipes, and a special valve is arranged between the high and low pressure cylinders permitting the engine to be worked simple or compound as desired. The exhaust is carried through a high exhaust pipe with a variable exhaust nozzle.

The boiler is of the Belpaire type, built of steel plates, with the exception of the inside fire-box, which is of copper. The firebox is between the frames and the grate is inclined toward the front at a very sharp angle. The staybolts in the water legs are of manganese bronze. The tubes are of the Serve pattern. The throttle valve is of the sliding type and is fitted with the pilot valve, which opens first. The pressure on the main valve is thus equalized and it may be readily moved upon its seat.

The frames are of the plate type and wrought iron driving boxes are used. The weight is transferred to the frames through underhung springs and forged steel equalizing beams.

The engine truck side frames are of a slab form placed inside the wheels. The weight is transferred to the truck through two hemispherical bearings, whose centers are 35½ in., being measured transversely. These bearings are seated in suitable castings which can slide on a heavy cast steel cross tie. Lateral motion of the truck wheels is also provided and is controlled by means of coiled springs. The center pivot supports no weight and is used simply for pushing the truck.

The tender is carried on six wheels, the two rear pairs of which are equalized. The frames are of the plate form placed outside of the wheels. The general dimensions of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 9 ins.
Service	Passenger
Fuel	Coal
Tractive power	21,466 lbs.
Weight in working order	152,900 lbs.
Weight on drivers	110,000 lbs.
Weight on leading truck	42,900 lbs.
Weight of engine and tender in working order	195,000 lbs.
Wheel base, driving	13 ft. 9.36 in.
Wheel base, total	27 ft. .08 in.
Wheel base, engine and tender	48 ft. 8.01 in.

CYLINDERS.

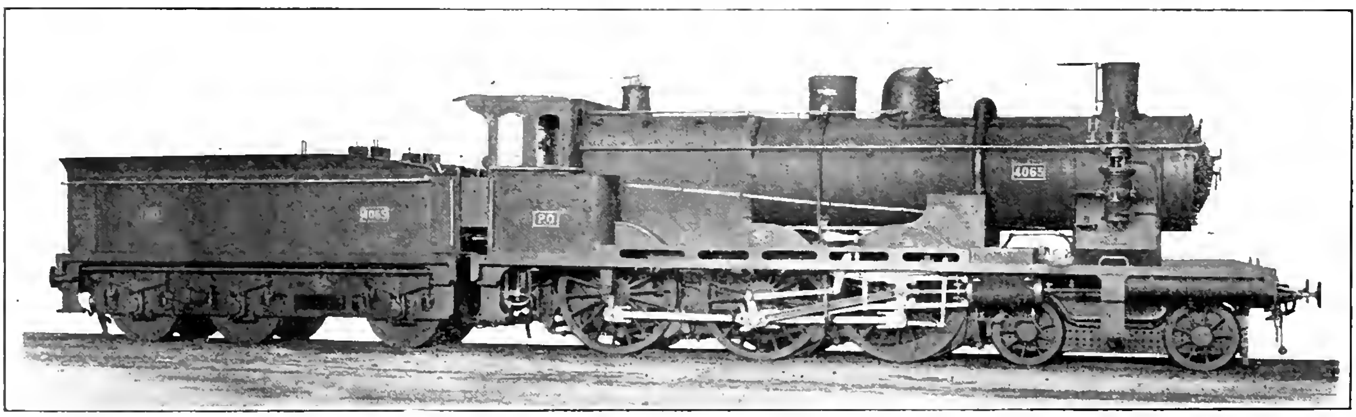
Kind	DeGlehn Comp.
Diameter	14.17 and 23.62 in.
Stroke	25.20 in.
Kind of valves	Slide

WHEELS.

Driving, diameter over tires	72.84 in.
Driving journals, diameter and length	8.55 x 9.1 in.
Engine truck wheels, diameter	37.8 in.
Engine truck journals	5.9 x 9.85 in.

BOILER.

Style	Belpaire
Working pressure	227 lbs.
Outside diameter of first ring	59.57 in.
Firebox, length and width	119.8 x 39.37 in.
Firebox plates, thickness	1.18 & .63 in.
Firebox, water space	S — 2.91 — F & B 3.74 in.
Tubes, number and outside diameter	139 — 2.76 in.
Tubes, length	14 ft. 7.39 in.
Heating surface, tubes	2402 sq. ft.
Heating surface, firebox	174 sq. ft.
Heating surface, total	2576 sq. ft.
Grate area	35.36 sq. ft.



DEGLEHN COMPOUND TEN-WHEEL LOCOMOTIVE—PARIS-ORLEANS RAILWAY.

AN APPRECIATION.

The following item, which is taken from the *Daily Railway Age*, has met with such hearty approval and so clearly expresses our own sentiments that we take this opportunity of giving it a wider circulation:

"Probably few of the members of the Master Mechanics' Association or others who have charge of the design and operation of railway repair shops appreciate fully their indebtedness to one who is rarely missing from any meeting of this association or

others having somewhat similar reasons for existence. Indefatigable in research, with unfailing memory for the slightest detail which may have a bearing upon the general principle involved, his chief work is of the kind that is largely done in seclusion or as an incident to more apparent but much less important work, and often appears to public gaze only under the guise of a plan, for which, frequently, if not always, the major credit goes elsewhere. Employed by one of the large corporations, that corporation itself has little knowledge of the work upon which he may have been engaged, when apparently not engaged at all, only as some improvement in design or method makes itself at last apparent as a valuable economic expedient.

"At the same time, in the true spirit of all scientific investigation the results of all his studies are ever at the service of those engaged in similar pursuits and it is this perhaps more than anything else, except his pleasing personality, which has given him his present place in the hearts of all railway mechanical men. The reference is obviously to Lewis R. Pomeroy, electrical expert on shops for the General Electric Company."

WHAT'S THE USE?

TO THE EDITOR:

Referring to the last two lines of the efficiency record of H. J. Doe, No. 44, on page 223 of your June issue:

Month	Total Time		Per Cent		Amount		Total Earnings
	Std.	Act.	Eff.	Bonus	Wages	Bonus	
March, 1907	322.8	250	129.	49.	85.00	41.65	126.65
April, 1907	322.6	233	138.5	58.5	79.22	46.34	125.56
	.2	17					1.09

With a difference of only .2 of an hour in the standard time, the man reduced the actual time 17 hrs., and received $1.09 less for it. Don't you think that John Doe will be inclined to say "what's the use?" MARVIN ELLIS.

YOUNGSTOWN, OHIO.

TO THE EDITOR:

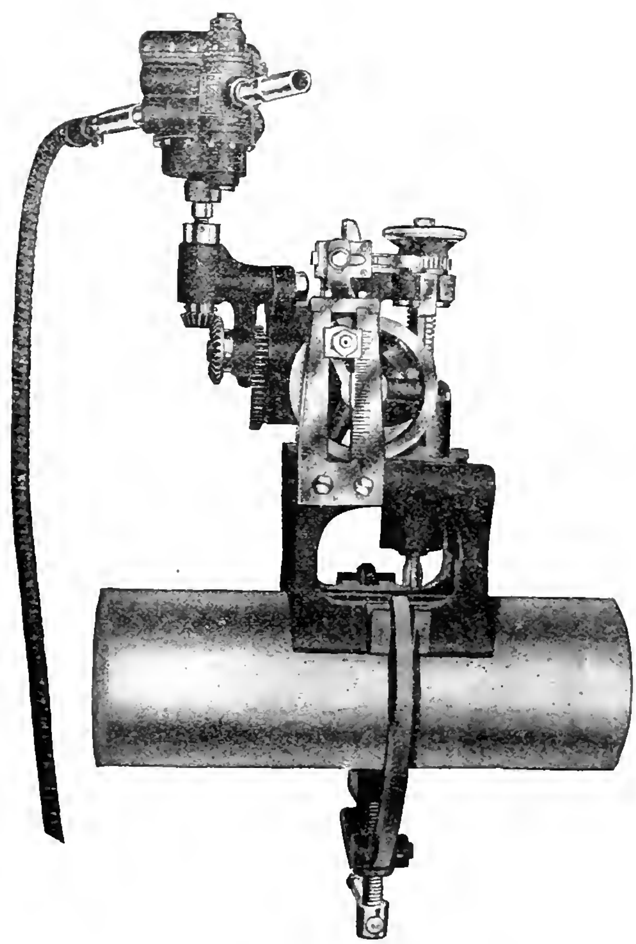
Under the day rate plan in operation at the Topeka Shops before individual effort was introduced, H. J. Doe, No. 44, received wages at the rate of $0.34 per hour. In the month of March, 1907, his wages were at the rate of $0.5066 per hour; in April, 1907, at the rate of $0.5388, an increase in one month of over 6.5 per cent. in hourly rate. Had Doe hired out for April at the hourly rate he was paid in March he would have received $7.52 less than was actually paid him in April.

Marvin Ellis cannot see the bonus payment above standard wages of $46.34, but somehow tries to make out that Doe was swindled out of $1.09. It does not occur to him that Doe's improvement was in part due, possibly largely due, to extra efforts on the part of the foreman, also bonused by the company; to extra expense incurred to furnish Doe promptly with suitable work; to extra expense incurred to see that he received good tools, and that his machine was in good condition. Whereas a piece work rate might have been $0.246 last year it was in March $0.3923 and in April $0.3892, an increase in the first case of $0.146 or 59 per cent., a decrease in the second case of $0.0031, or less than eight-tenths of one per cent. The grasping employer would in fact be shameless enough to go further. If next month Doe delivers 500 standard hours in 250 actual hours, thus showing an efficiency of 200 per cent., his wages will only be increased 120 per cent., his bonus will be only $104, his total pay only $189 and his piece work rate will drop to $0.378. That is the plan under which the unfortunate H. J. Doe works and if he does not like it he can drop back to an efficiency of 90 per cent., earn $8.50 bonus instead of $46.34, but have the supreme satisfaction of working on a piece rate of $0.446.

INDIVIDUAL EFFORT.

PORTABLE AUTOMATIC KEY SEATING MACHINE.

A machine, the usefulness of which can thoroughly be appreciated by all locomotive men by an inspection of the accompanying engraving, has recently been designed and is now being sold by Joseph T. Ryerson & Son, Chicago. The machine is designed for automatically cutting key-ways in locomotive axles, either before or after the engine is assembled. Its operation is entirely automatic when once the machine is in place and set for the proper length key-way. It takes up a space of but 8½ in. on the axle. It weighs but 100 lbs. and is driven by either an air or electric motor, which should operate between 300 and 450 r. p. m. It is designed so that it will cut as close as 1 in. to a driving box or eccentric and the adjustment is such that any



RYERSON AUTOMATIC KEY SEATING MACHINE.

standard size key-way can be cut. It is arranged for use with either new axles or for re-cutting the key-way in an old axle to correspond with the change in the location of the eccentric, thus obviating the necessity of using an off-set key. The machine can be operated in any position on the axle. The time required for cutting a 1 x ½ x 6 in. key-way cannot exceed 35 minutes. The cutters are furnished with the machine and are of special design and made from the best quality of high speed tool steel.

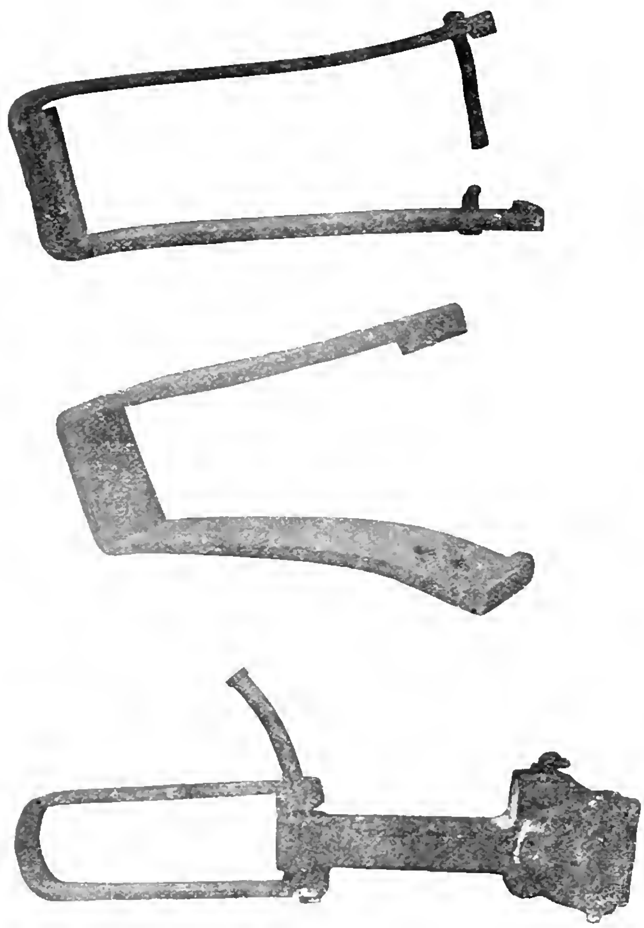
One of these machines was shown in operation at the exhibition at Atlantic City during the mechanical conventions and attracted a large amount of interested attention, which was universally followed by favorable comment.

REFINEMENTS IN DESIGN AND CONSTRUCTION.—There is no doubt that the further development of the steam locomotive will be accompanied by the more extensive introduction of refinements in design and construction, tending to improve the efficiency of the machine. This will necessitate better shop and round house equipment, in order that the motive power may be properly maintained, and worked to best possible advantage.—*Paul T. Warner before the Franklin Institute.*

RADIAL COUPLER AND IMPROVED COUPLER YOKE CONNECTION.

An improved method of connecting the drawbar to the yoke has recently been patented by Mr. J. J. Tatum, general foreman of the car department at the Baltimore Terminals of the Baltimore & Ohio Railroad and by Mr. Alois P. Prendergast, a master mechanic of the same company.

The principal advantages of the device are the dispensing with rivets, its radial feature and the resulting increase in train tonnage with the same locomotive tractive force on divisions where curves are numerous, the great increase in strength as compared to the ordinary type of coupler yoke fastening and the ease with



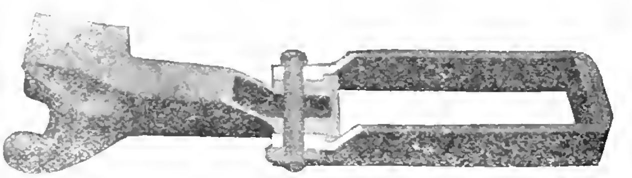
FAILURES OF ORDINARY TYPE OF COUPLER YOKE, AND PIN.

which the yoke may be removed or applied to a drawbar without special facilities and by trainmen or others not skilled in this work. Those who are acquainted with the weaknesses developed by the present type of fastening and the need for a radial coupler can readily understand the marked advantages of this new device from the following description and the drawings.

The bosses on the arms of the yoke are either welded on or the end may be upset and forged to the shape shown in the illustration. These bosses engage with the shoulders on the end of the drawbar. The yokes are now being made on an Acme 3½-in. bolt machine and are fitted to the coupler without any machining. The bosses and shoulders are slightly undercut, so that the tendency under tension is to draw the arms of the yoke together. The pin which ties the two parts together does not take any of the load, and is simply used to prevent the yoke from slipping laterally. The advantages of the radial feature are well understood. The flexible coupler yoke connection eliminates the damaging side shearing effect that is met with in the riveted rigid method of fastening the coupler yoke to the drawbar, now in general use. It reduces the wear of the wheel flanges and rail and greatly reduces the number of accidents due to the breakage of the wheel flanges. It also reduces the side stresses on the car framing and the wear of the coupler and breakage of coupler shanks. Loss of time and the expense of getting cars over sharp curves are eliminated.

The method of making the connection is very simple and inexpensive as compared to the time and cost of applying the ordiordinary type of yoke. The coupler or coupler yoke may be removed and replaced on the line by trainmen or section hands without sending the car to the repair tracks, thus effecting a considerable time-saving as well as reducing the expense.

The strength of the connection is so much greater than that of the present standard that tearing apart will be practically eliminated by its use. The pulling apart of the drawbar and yoke is due to the pulling stresses or shocks, and to gain some idea of



TATUM-PRENDERGAST YOKE.

the relative strength of this form of connection as compared to the ordinary type under such conditions, tests were made under the M. C. B. drop testing machine at Mount Clare.

The two yokes were 1¼ ins. thick and the one for the radial connection was 4½ in. wide or ½ in. wider than the standard yoke because of the 2¼-in. hole, for the pin, in the bosses. The lips on the standard yoke were carefully fitted over the tail of the coupler.

The results of these tests were as follows:

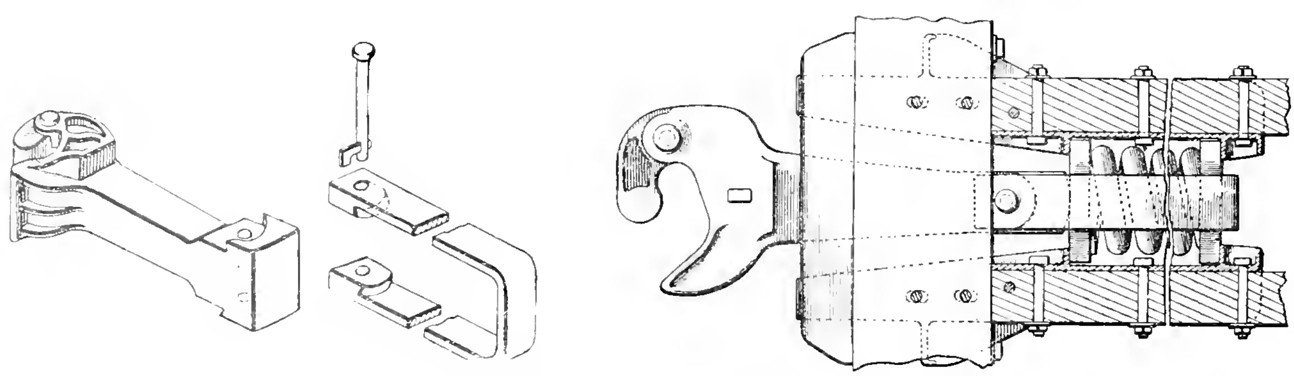
TATUM-PRENDERGAST YOKE.

No. of Blows.	Height.	Rebound.	Remarks.
1	1 ft.	½ in.	
2	2 "	1 "	
3	3 "	1 "	
4	4 "	1 "	
5	5 "	3 "	Cracked at back fillet.
6	6 "	3 "	
7	7 "		Fracture at both back fillets.

This yoke was destroyed without affecting connections at the drawbar.

M. C. B. YOKE.

No. of Blows.	Height.	Rebound.	Remarks.
1	1 ft.	½ in.	
2	2 "	1 "	
3	3 "	1 "	One of the lips cracked.
4	4 "	1 "	
5	5 "		The other lip broken off and both 1¼-in. rivets sheared.

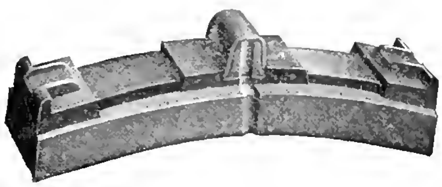


TATUM-PRENDERGAST YOKE AND ITS APPLICATION.

Some of these couplers have been in service for about a year with very satisfactory results. It is possible to arrange the rear end of the drawbar so that it will take either this or the standard yoke.

ARMBRUST BRAKE SHOE.

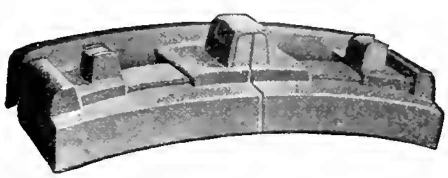
The brake shoe illustrated herewith is adapted for locomotives, tenders, and passenger and freight cars. It differs from other types of brake shoes in several important features, among which are the following: The shoes are scored across the middle so that any accidental breakage will occur at that point; spacing lugs are cast on the back of the shoe to space the shoe body away from the brake head, thus enabling it to wear entirely out



ARMBRUST CAR SHOE.

without danger of wearing the head, even if it should wear unevenly; a steel connector is cast in the spacing lugs, which construction does not weaken the shoe body.

The scoring of the shoe at the center causes any breakage to occur at that point and permits the shoe to adjust itself to the tread of the wheel, thereby giving better service and adding to the life of the shoe. It also enables the shoe to fit the brake-head at four points of contact, taking the strain off the shoe and throwing it on to the brake-head, where it properly belongs. The steel connector which is cast in the spacing lugs holds the broken parts together in case of breakage which might occur at other points than at the center, thus obviating all danger of



ARMBRUST DRIVER SHOE.

wrecks due to a broken shoe falling to the track. This feature is especially attractive for elevated roads, as there is no danger of broken parts falling to the street.

The body of this shoe, which is known as the Armbrust shoe, can be worn entirely out and is said to be as safe for the last one-quarter inch of wear as at the first. The scrap remaining in a car shoe amounts to about 3 lbs. and in a driver shoe to about 10 lbs.

The driver brake shoe may be pinned to the brake-head the same as the car shoe, or it may be constructed to hook and bolt on the brake-head. With the former construction it is not necessary to have rights and lefts, and therefore the amount of stock which it is necessary to carry can be reduced. This feature permits the shoes to be turned when they are worn more on one end than on another. These brake shoes are manufactured by the Love Brake Shoe Company, whose offices are in the Fisher Building, Chicago, and who at present have foundries at Aurora, Ill.; Augusta, Ga., and Davenport, Ia.

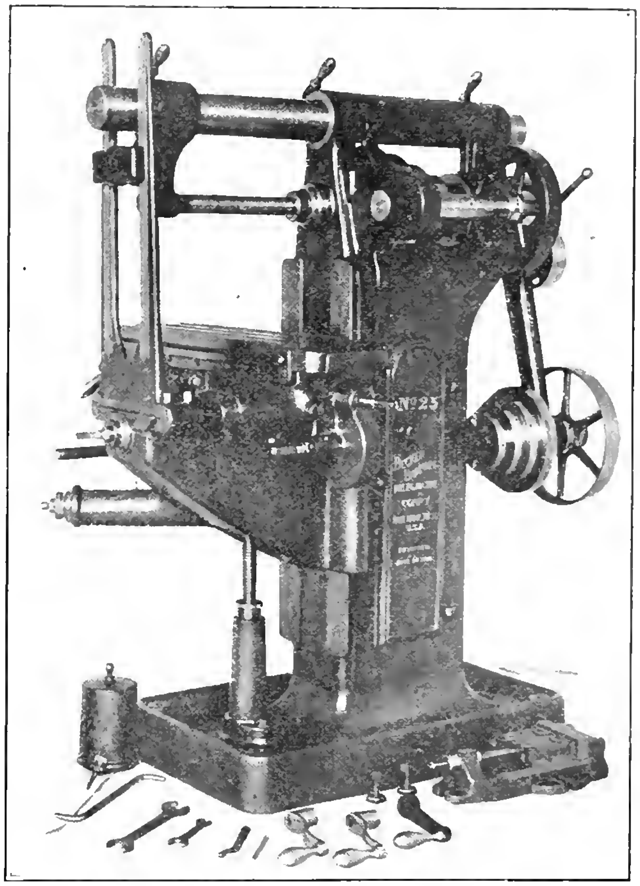
THE RAILROADS.—A commonwealth is dependent upon transportation facilities for its development, and railroads that make large expenditures to render good service at a reasonable cost for the welfare and prosperity of the people who occupy the lands adjoining their tracks, are entitled to reciprocal consideration and an opportunity to expand.—*Mr. J. E. Muhlfeld, before the Railway Club of Pittsburgh.*

PLAIN HORIZONTAL MILLING MACHINE.

The plain horizontal milling machine, shown in the illustration, may be furnished either with or without back gears. Special attention has been given to designing the feed works to withstand the full power of the driving belt and to give good service under rough usage. The feed mechanism is driven by a belt connected to an auxiliary spindle, which receives its motion from the main spindle through a train of gears, so arranged that the belt velocity is sufficient to drive all the feeds that the main belt will stand. The changes of feed are furnished by the four step cones and by interchanging the feed driving pulleys at the rear of the machine, thus giving a total of eight changes from .007 to .100 in.

The table is operated by a worm and a hobbed rack, the worm being of coarse pitch and driven by a large size gear. The feed may be disengaged by means of a novel drop worm mechanism, which overcomes the objection to the old style gravity drop worm of clinging to the gear by friction alone; it also equalizes the wear on the worm gear teeth. The worm is engaged and disengaged by the same lever. The table has a hand quick return of 4 to 1 ratio.

The knee of the machine has been lengthened so that a har-



BECKER-BRAINARD PLAIN HORIZONTAL MILLING MACHINE.

ness brace may be used for the arbor and still leave a cross range for the table equal to that of the old style machines. This harness consists of a brace which is gibbed to the knee slide and a clamp that is fastened to the arbor support yoke in such a way as to allow it to be swiveled around its centers, allowing the brace to be taken off without removing any bolts. This makes a very stiff brace and the device as a whole adds greatly to the convenience of the machine, as well as increasing the rate at which the work may be handled. The arm is a solid steel bar, which is adjustable lengthwise. The machine has a rigid box knee with a telescopic elevating screw, thus allowing it to be set in any position without regard to the beams or floor construction, as the screw does not project below the floor line. The base is quite similar to other Becker-Brainard machines in that it is extra heavy and capable of absorbing all vibrations. The spindle, cone and back gears are of the standard Becker-

Brainard design. The wear of the spindle bearings is taken up by concentric compensating bronze boxes. These machines are made by the Becker-Brainard Milling Machine Company, Hyde Park, Mass. They have a longitudinal feed of 34 in., a cross feed of 8 in., a vertical adjustment of 18 in. and weigh about 1,650 lbs.

IMPROVED PIPE THREADING AND CUTTING OFF MACHINE.

The accompanying illustrations show the largest and next to the smallest of five sizes of improved pipe threading and cutting off machines, which are made by the Armstrong Manufacturing Company of Bridgeport, Conn. These machines are simple, compact and strong in proportion to their weight. The two smaller sizes may be operated either by hand or power, the smaller one taking from ¼ to 2 in. pipe and weighing, with the dies, about 135 lbs. The largest size cuts and threads pipe from 1 to 6 in. in diameter, and weighs about 1,250 lbs. These machines may also be used for threading bolts, the one shown in Fig. 2 taking bolts from ½ to 1½ in. in diameter.

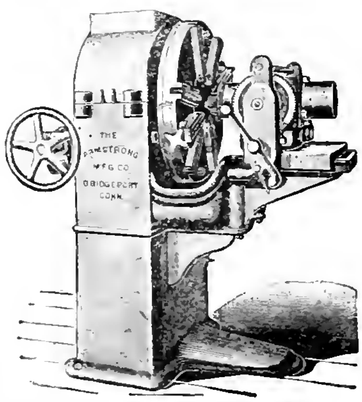


FIG. 1.

The pipe is gripped in a powerful self-centering vise which for the two smallest sizes may be screwed to a post, bench, or any temporary support, and with the larger sizes is permanently built in the stand of the machine. The vise handle is arranged to be out of the way of the operator when threading or cutting, and yet be convenient when it is needed. In front of the vise is the die head carrying a machine counterpart of the Armstrong adjustable stock for hand threading, the die being divided into from two to eight sections, depending upon the size of the pipe. In the two-part dies adjustment is made by individual end screws but in the larger sizes the die sections are moved simultaneously, like the jaws of a lathe chuck, by turning a single screw. The dies used are of the Armstrong make, with their characteristic adjustable features and double taper. They are furnished right or left handed, for pipe or bolts, as may be desired.

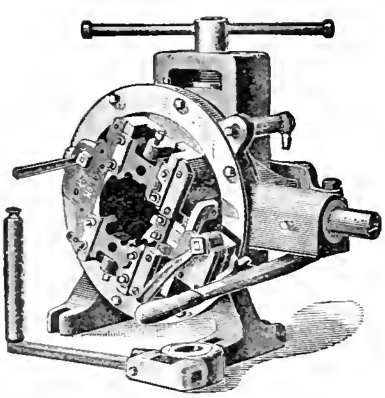


FIG. 2.

The die head has no gear teeth on the part coming in contact with the shell, while a generous bearing insures firmness and little wear. The driving spindle is carried through the side and its end is squared in the smallest size and provided with a key in the larger sizes, so that a hand crank or power pulley can be slipped on or off at a moment's notice. In the smallest size machine there is a geared spindle in addition to the main driving spindle, so that two speeds are provided, enabling small pipe to be threaded very quickly and giving less speed and more power for pipe from 1¼ to 2 in. This feature is said to be unique in this class of tools; its advantages are manifest.

After the pipe has been threaded a simple motion of the hand wheel or lever causes the die to open. The pipe may then be pushed through and cut off to the proper length. All parts are numbered and are fitted to be interchangeable with others of the same number, so that these machines need not be sent to the factory for repairs. These machines will thread and cut off a quarter inch pipe in two and one-half and a six inch pipe in four minutes, with proportionate time for intermediate sizes. All the gears and bearings are enclosed in a dust-proof oil-chamber and good lubrication is thus insured, as well as protection from dust, dirt and metal chips.

The two smaller sizes, the larger of which is shown in Fig. 2, and which will cut 4 in. pipe, can readily be moved to outside work.

NEW TYPE OF MONKEY WRENCH.

One of the smaller exhibits at the Atlantic City exhibition last month, which attracted a large amount of attention, was that of the Bald Manufacturing Company, 603 Farmers' Bank Building, Pittsburg, which exhibited a single monkey wrench of new design, known as the "Miller" wrench. It differs from other wrenches in that the lower jaw is quickly adjusted to a nut by means of a thumb lever, which releases a cam and allows a spring to force the jaw to its adjustment. Upon the release of the thumb lever an eccentric worm is thrown into action which positively locks the jaw in place and allows the wrench to be used on that size nut as often as desired without further adjustment.

Furthermore, the construction of the wrench is such that the strain is practically all on the jaws. Since the operation is all performed by one hand and the adjustment is immediate and accurate the wrench has a big claim as a time saver. This is one of the many new things shown at the exhibition which have great future possibilities.

PERSONALS.

Mr. D. C. Ross has been appointed master car builder of the Michigan Central R. R., with office at West Detroit, Mich.

Mr. B. S. Hinckley has been appointed engineer of tests of the N. Y., N. H. & H. R. R., with headquarters at New Haven, Conn.

Mr. C. M. Harris has been appointed master mechanic of the Washington Terminal Company, with headquarters at Washington, D. C.

Mr. David Holtz, master of machinery of the Western Maryland R. R., with office at Union Bridge, Md., has resigned and the office has been abolished.

Mr. A. E. Mitchell has been appointed manager of purchases and supplies of the New York, New Haven and Hartford Railroad, with headquarters at New Haven, Conn.

Mr. John Nicholson has been appointed superintendent of motive power of the St. Louis, Brownville & Mexico Ry. at Kingsville, Tex., succeeding Mr. H. H. Kendall.

Mr. M. N. Forney, author of "The Locomotive Catechism," at one time part owner and editor of the *Railroad Gazette* and for many years editor of the AMERICAN ENGINEER AND RAILROAD JOURNAL, was married on June 25 to Mrs. Annie Virginia Spear of Baltimore.

Mr. H. J. Tierney has been appointed mechanical engineer of the Missouri, Kansas & Texas Ry., with office at Parsons, Kan.

Mr. J. B. McIntosh has been appointed superintendent of heat, light and power of the Washington Terminal Company, with headquarters at Washington, D. C.

Mr. A. W. Wheatley, assistant superintendent of motive power and machinery of the Union Pacific, has resigned to become general inspector of the American Locomotive Co. at Schenectady, N. Y.

BOOKS

Tests of Metals. 1906. A report of the tests made on the U. S. testing machine at the Watertown Arsenal, Mass., during the year ending June 30, 1906. Published by the Government Printing Office, Washington, D. C. Address Chief of Ordnance, War Department, Washington, D. C. 645 pages. Cloth, 6 x 9.

This book contains a complete account of the results of the tests made by the government during the past year on various metals and other materials for industrial purposes, which include steel castings and forgings, cast iron, bronze, copper, steel wire, hardened steel balls, steel ingots, rotating shafts, railroad material, concrete, reinforced concrete, brick, sand and paper. It is profusely illustrated with excellent photographs and includes a vast amount of very valuable material.

CATALOGS.

In writing for these catalogs please mention this journal.

SMITH NUT LOCK.—A small folder describing the new nut lock which is manufactured by the Keystone Nut Lock Mfg Company, Commonwealth Building, Pittsburgh, Pa.

STROUSE LOCOMOTIVE STOKER.—The Locomotive Stoker Co., Chicago, is issuing a leaflet describing and illustrating its latest design of stoker which has been in successful service on one of the western roads for a number of months.

"MORE HOLES FOR LESS MONEY."—A small but interesting pamphlet from The Knecht Brothers Company, Cincinnati, Ohio, telling of the advantages of the Knecht friction sensitive drill which may be furnished for either a belt or motor drive.

BOILER SHOP MACHINE TOOLS.—The Queen City Punch & Shear Company, Cincinnati, Ohio, has prepared a number of loose leaves describing their punching and shearing machinery and straightening and bending rolls. They are sending these out in neat and simple binders.

BULLETIN ON ELECTRIC GENERATORS AND MOTORS PRINTED IN SPANISH.—The Triumph Electric Company, Cincinnati, Ohio, is issuing bulletin No. 311, which illustrates and describes its line of steel frame generators and motors, printed in Spanish.

VERTICAL TURRET LATHE.—A small, handsomely illustrated pamphlet describing the vertical turret lathe manufactured by The Bullard Machine Tool Company, Bridgeport, Conn. The inside cover page bears this inscription: "A multi-purpose tool for increasing output and decreasing cost of all face plate work within its range."

THE COUR-CASTLE CORRUGATED LOCOMOTIVE FIREBOXES.—A. M. Castle & Co., 55 N. Jefferson Street, Chicago, is issuing a small catalog descriptive of their depressed, corrugated side sheets. This type of side sheet was illustrated and described in the June issue of this journal, page 247. The catalog also contains a number of complimentary letters from prominent railway officials.

COLUMBIA UNIVERSITY: SUMMER SCHOOL.—The announcement of the courses in engineering, which will be conducted in the summer sessions of Columbia University, beginning July 9th and ending August 17th, is given in a small leaflet now being distributed. This announces two courses in civil engineering and three in mechanical, each of which are given by men prominent in their respective fields and are intended principally for instructors in engineering schools and for technical graduates who desire to keep up to date in their special lines. No examination is required for admission to this school.

THE MODERN CAR FOR PASSENGER TRANSPORTATION.—A booklet of 52 pages, handsomely illustrated, giving a short résumé of the evolution of the steel passenger car as constructed by the Pressed Steel Car Company together with brief descriptions of several types of such cars recently built. One prominent mechanical railway engineer, after glancing over a copy of it at the Atlantic City convention remarked as he put it in his side pocket: "This is worth while taking back home to put in my technical library."

IMPROVEMENT IN LOCOMOTIVE BOILERS.—Mr. William H. Wood, Engineer, Media, Pa., is issuing a small pamphlet descriptive of a number of proposed improvements in locomotive boilers which suggest changes in construction so as to prevent concentration of the stresses, caused by the expansion of the different parts, at the sharp flanges. These suggestions are interesting and worthy of study.

SMALL TOOLS, STANDARDS AND GAUGES.—The Pratt & Whitney Company, Hartford, Conn., is issuing catalog No. 4, which comprises 215 pages, thoroughly illustrating and describing the large and complete line of small tools, standards and gauges for which this company is famed. The book contains complete data, with prices, of the different tools, and also includes some valuable information in the shape of tables of dimensions of standard screw threads, taps, metric standards, weights, etc.

THE STEAM LOCOMOTIVE OF THE FUTURE.—The Baldwin Locomotive Works is issuing Record No. 61, containing an article by Mr. Lawford H. Fry on the above subject. This article appeared in *Cassier's Magazine* in January, 1907, and is one of the best discussions of what the ultimate result of the present tendency in locomotive practice will be, that has appeared in recent years. Mr. Fry includes foreign as well as American locomotives in his discussion, and draws some very rational and interesting conclusions from the study.

EIGHT-WHEEL TYPE PASSENGER LOCOMOTIVES.—A pamphlet recently issued by the American Locomotive Company illustrates and describes different designs of 8-wheel or American type passenger locomotives. This is the eighth of the series of pamphlets which is being issued by this company to cover the various standard types of locomotives. It contains illustrations of 25 different designs of 8-wheel type engines, the principal dimensions of each design being given on the page opposite the illustration. The pamphlet constitutes a very complete record of the production of the company in this type of engine, and the arrangement is very convenient for the selection of a design best suited to meet any particular requirement.

TRACK SUPPLIES AND RAILWAY MATERIAL.—The Buda Foundry & Manufacturing Company, Chicago, Ill., is issuing a cloth bound catalog containing 329 pages, which very thoroughly illustrates and describes the large and varied line of track supplies and material manufactured by this company. This includes track scales, hand push cars, velocipedes, switch stands, ball bearing jacks, and in fact all tools and devices required by the maintenance of way department of a railroad. Among the features in this catalog which are of special interest to the motive power department, are the ball bearing hydraulic, locomotive and car jacks, as well as geared ratchet jacks and hydraulic journal box jacks. These are shown in many sizes and capacities and include several special designs for particular classes of work. The section on car and engine replacers will also be found interesting by motive power men. This part of the catalog contains a number of illustrations showing the Buda replacers in actual service under different conditions.

GRINDING MACHINES.—The Norton Grinding Company is issuing Catalog N-7, entitled, "Norton Plain Machines for Cylindrical Grinding." This is in pamphlet shape, of a size corresponding to the publications issued by the locomotive companies, and contains 63 very interesting pages of information and illustrations on the subject of grinding machines. The machines illustrated, each one of which is shown and described separately, include twelve of the over-head drive type in sizes varying from 6 x 32 in. to 18 x 168 in. Seven machines of the electric drive type are shown in sizes from 10 x 50 to 14 x 72 in., including a car wheel grinder. Six machines of the self-contained electric drive type are shown in sizes varying from 18 x 96 to 18 x 168 in., also including a car wheel grinder. The first and last of these types includes a gap machine, in which piston rods can be ground without removing the piston head. Several illustrations of the work performed on these machines is included, as well as views of the Norton factory at Worcester, Mass. The typographical work of this catalog is excellent, the illustrations being particularly clear and distinct.

SCHOOL OF RAILWAY ENGINEERING.—The University of Illinois is issuing bulletin No. 8 of Vol. 4, descriptive of the new school of Railway Engineering and Administration recently organized. It is stated that the function of this school is to coordinate the various facilities of this university so as to provide specialized training for all branches of railway service and to otherwise further this work. It is the purpose of this school to provide courses of training which shall prepare men to become efficient workers in the financial, traffic and operating, as well as in the engineering departments of both steam and electric railways. At present there are offered the following four courses: railway civil engineering; railway electrical engineering; railway mechanical engineering and railway administration. Each of these occupies four years and the work in each course has been carefully selected to meet modern conditions. The bulletin gives the courses in detail and contains complete information on the material equipment of the university used in this school. The men chosen as instructors have been carefully selected for their fitness and experience, in fact so much care is being given to this point that the position of Professor of Railway Engineering has not yet been filled. This position will require a man of exceptional ability and one who has had experience in the maintenance of way department of railways, as he will be expected to give instruction in the civil engineering courses. The proper man no doubt will be found before the opening of the school next fall. Copies of this bulletin can be obtained by any one interested by addressing the University of Illinois, Urbana, Ill.

Pressure Gauges, Indicators, etc.—The Ashcroft Manufacturing Company, 85 Liberty St., New York, is issuing a 155-page cloth bound catalog which contains brief but complete descriptions of the various specialties, instruments and tools manufactured by this company. These include pressure gauges of all kinds and capacities, automatic recording gauges, revolution counters, gauge boards and panels, gauge testing machines, low water alarms, Tabor steam and gas engine indicators, planimeters, pipe stocks and dies, ratchets, sockets, etc. The typographical work in the book is excellent, the illustrations being printed on heavy coated paper, making them unusually distinct and valuable.

Electrical Apparatus.—The General Electric Company is issuing a number of new bulletins. These include No. 4505, which illustrates and describes the new design of commutator pole railway motors, which are at present furnished in sizes varying from 50 to 200 h.p. Bulletin No. 4503 illustrates and describes in detail the CQ generators and balancing sets, which are furnished in capacities ranging from 1½ k.w. to 17 k.w., intended for slow or moderate speeds. No. 4502 is on the subject of knife-blade lever switches, and shows many types and sizes. No. 4493 is a 76-page bulletin giving the parts of R controllers. This is very complete and gives the number, name and price of each separate part of the many different designs of these controllers. The same company is also issuing a pamphlet descriptive of the electrification of the West Jersey & Sea Shore Railroad. This gives complete illustrations of the apparatus and equipment and a brief description of the interesting features.

NOTES

American Malleables Company.—Mr. D. J. Carson, who has been in charge of the New York office of the American Brake Shoe & Foundry Company for the past two years, has been appointed manager of the above company.

The Arnold Company.—This company announces that Mr. Alfred R. Kipp, who is a specialist in railway shop work, has recently joined its engineering staff. Mr. Kipp has been in active railroad service since his graduation from Purdue in 1896.

Joseph Dixon Crucible Company.—At a special meeting of the directors of the above company, held May 31, to take action on the recent death of vice-president and treasurer, Mr. John Walker; Mr. George T. Smith was elected vice-president, Mr. George Long, treasurer, and Mr. Harry Daily, director and secretary.

Cutler-Hammer Manufacturing Company.—This company which has recently purchased the Wirt Electric Co., of Philadelphia, announces that the manufacture of Wirt apparatus, certain types of which, particularly battery charging rheostats and field rheostats, enjoy an enviable reputation, will be continued by it. The current Wirt catalog should be used for the present. The address of Cutler-Hammer Mfg. Co. is Milwaukee, Wis.

Chicago Pneumatic Tool Company.—The following cablegram was recently received by the company from its London office. "Boyer Hammer patent sustained by highest English court. Certificate of validity furnished. Competitors taxed with costs and damages—all hammers made declared infringement—decision very important as British patent corresponds to our American patent and covers all practical hammers. Hardest fought and most expensive ligation ever conducted involving a pneumatic tool."

Keith and Proctor's Jersey City Theatre.—This theatre, which is the latest addition to Jersey City playhouses and is as complete in its luxurious appointments as most of the Manhattan theatres, is acquiring a wide reputation for its excellent attractions, its low prices and its comfort, particularly for women and children. Each matinee ticket at 10 or 20 cents entitles its holder to a number in a prize drawing contest, the prizes being cut glass or jewelry. The building is artificially cooled, and is thoroughly comfortable even on the warmest days.

Unfair Methods in Competition.—S. F. Bowser & Co., Fort Wayne, Ind., has filed a suit in the U. S. District Court at Cincinnati against the National Oil Pump and Tank Company, of Dayton, which charges most unfair methods in competition. This action is supplementary to suit for infringement of patents, which was filed against the same company some months ago and is now pending. It is charged in the later suit that the National Company has closely copied the Bowser cuts and advertising matter, and that it has constructed its goods to closely resemble the Bowser products, thus misleading the customers and taking an unfair advantage of the reputation of the Bowser tanks and pumps.

CONVENTION EXHIBITS.

There were 257 exhibitors at the M. M. and M. C. B. conventions, or 13 more than last year. The uniform arrangement of the booths greatly improved the appearance and the exhibits themselves were more complete than usual. Among the exhibitors were the following:

American Balance Valve Co., Jersey Shore, Pa.
American Blower Co., Detroit, Mich.
American Brake Shoe & Foundry Co., Mahwah, N. J.
American Engineer and Railroad Journal, New York.
American-Henderson Roller Bearing Co., Chicago, Ill.
American Nut and Bolt Fastener Co., Pittsburg, Pa.
American Locomotive Co., New York.
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
American Steel Foundries, Chicago.
Armstrong Bros. Tool Co., Chicago.
Atha Steel Casting Co., Newark, N. J.
Baeder, Adamson & Co., Philadelphia.
Besly, Chas. H. & Co., Chicago.
Bethlehem Steel Co., South Bethlehem, Pa.
Bettendorf Axle Co., Davenport, Iowa.
Bickford Drill & Tool Co., Cincinnati, O.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bliss Electric Car Lighting Co., Chicago.
Bordo L. J. Co., Philadelphia, Pa.
Bowser & Co., S. F., Fort Wayne, Ind.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Buckeye Steel Castings Co., Columbus, O.
Buda Foundry & Mfg. Co., Chicago.
Buffalo Brake Beam Co., New York.
Bullard Machine Tool Co., The, Bridgeport, Conn.
Burnham, Williams & Co., Philadelphia.
Butler Drawbar Attachment Co., The, Cleveland, O.
Cardwell Mfg. Co., Chicago.
Carey Mfg. Co., The Philip, Lockland, Cincinnati, O.
Chicago Car Heating Co., Chicago.
Chicago Pneumatic Tool Co., Chicago.
Cleveland Car Specialty Co., Cleveland, O.
Cleveland Pneumatic Tool Co., Cleveland, O.
Commercial Acetylene Co., New York.
Commonwealth Steel Co., St. Louis, Mo.
Consolidated Railway Electric Lighting & Equipment Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
Davis Pressed Steel Co., Wilmington, Del.
Dearborn Drug & Chemical Co., Chicago.
Detroit Lubricator Co., Detroit, Mich.
Dickinson, Paul, Inc., Chicago.
Dill, T. C., Machine Co., Philadelphia, Pa.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Dressel Railway Lamp Works, The, New York.
Drouve Co., The, Bridgeport, Conn.
Dudgeon, Richard, New York.
Duner Co., Chicago.
Falls Hollow Staybolt Co., Cuyahoga Falls, O.
Farlow Draft Gear Co., Baltimore, Md.
Firefight Paint Co., Pittsburgh, Pa.
Flannery Bolt Co., Pittsburgh, Pa.
Flexible Compound Co., The, Philadelphia.
Forsyth Bros. Co., Chicago.
Fox Machine Co., Grand Rapids, Mich.
Franklin Mfg. Co., Franklin, Pa.
Franklin Railway Supply Co., Franklin, Pa.
Frost Railway Supply Co., The, Detroit, Mich.
Galena-Signal Oil Co., Franklin, Pa.
General Electric Co., Schenectady, N. Y.
Gold Car Heating Co., New York.
Goodwin Car Co., New York.
Gould Coupler Co., New York.
Greene, Tweed & Co., New York.
Grip Nut Co., Chicago-New York.
Hale & Kilburn Mfg. Co., Philadelphia.
Hammett, H. G., Troy, N. Y.
Helwig Mfg. Co., St. Paul, Minn.
Hess-Bright Mfg. Co., Philadelphia.
Home Rubber Co., Trenton, N. J.
Homestead Valve Mfg. Co., Pittsburgh, Pa.
Houghton & Co., E. F., Philadelphia, Pa.
Hunt-Spiller Mfg. Corporation, Boston, Mass.
Independent Pneumatic Tool Co., Chicago, Ill.
Jenkins Bros., New York.
Kennicott Water Softener Co., Chicago, Ill.
Kent & Co., Edwin R., Chicago.
Keystone Nut Lock Mfg. Co., Pittsburgh, Pa.
Kinnear Mfg. Co., The, Columbus, O.
Koppel Co., Arthur, Pittsburgh, Pa.
Lawrence Mfg. Co., Philadelphia, Pa.
Livezey, John R., Philadelphia.
Locomotive Stoker Co., The, Chicago.
Lodge & Shipley Machine Tool Co., Cincinnati, O.
Lord Co., Geo. W., Philadelphia.
Love Brake Shoe Co., Chicago.
Lucas & Co., John, Philadelphia, Pa.
McConway & Torley Co., The, Pittsburgh, Pa.
McCord & Co., Chicago.
Michigan Lubricator Co., Detroit, Mich.
Nathan Mfg. Co., New York.
National Malleable Casting Co., The, Cleveland, O.
National Railway Publication Co., New York.
Norton, A. O., Boston, Mass.
Norton Co., Worcester, Mass.
Parker Anti-Freezing & Hot Water System, London, Ont.
Perry Side Bearing Co., Chicago.
Pittsburgh Equipment Co., Pittsburgh, Pa.
Pocket List of Railroad Officials, New York.
Railway Age, The, Chicago.
Railway & Engineering Review, Chicago.
Railroad Gazette, New York.
Railway List Co., The, Chicago.
Railway Master Mechanic, Chicago.
Railway World, The, Philadelphia.
Ralston Steel Car Co., Columbus, O.
Refined Iron & Steel Co., Pittsburgh, Pa.
Republic Railway Appliance Co., St. Louis, Mo.
Resteine Co., Clement, Philadelphia.
Ryerson & Son, Joseph T., Chicago.
Safety Car Heating & Lighting Co., New York.
Sellers, Wm. & Co., Inc., Philadelphia.
Shelby Steel Tube Co., Pittsburgh, Pa.
Societe Generale des Freins Lipkowski, Paris, France.
Standard Coupler Co., New York.
Stoever Foundry & Mfg. Co., Myerstown, Pa.
Symington, The T. H., Co., Baltimore, Md.
Underwood & Co., H. B., Philadelphia, Pa.
Walworth Mfg. Co., Boston, Mass.
Watson-Stillman Co., New York.
Waugh Draft Gear Co., Chicago.
Western Railway Equipment Co., St. Louis, Mo.
Western Tool & Mfg. Co., Springfield, O.
Western Tube Co., Kewanee, Ill.
Westinghouse Air Brake Co., Pittsburgh, Pa.
Wheel Truing Brake Shoe Co., The, Detroit, Mich.
Wilmarth & Morman Co., Grand Rapids, Mich.

(Established 1832).
AMERICAN
ENGINEER
AND
RAILROAD JOURNAL.

AUGUST, 1907

100,000 LB. CAPACITY DYNAMOMETER CAR.

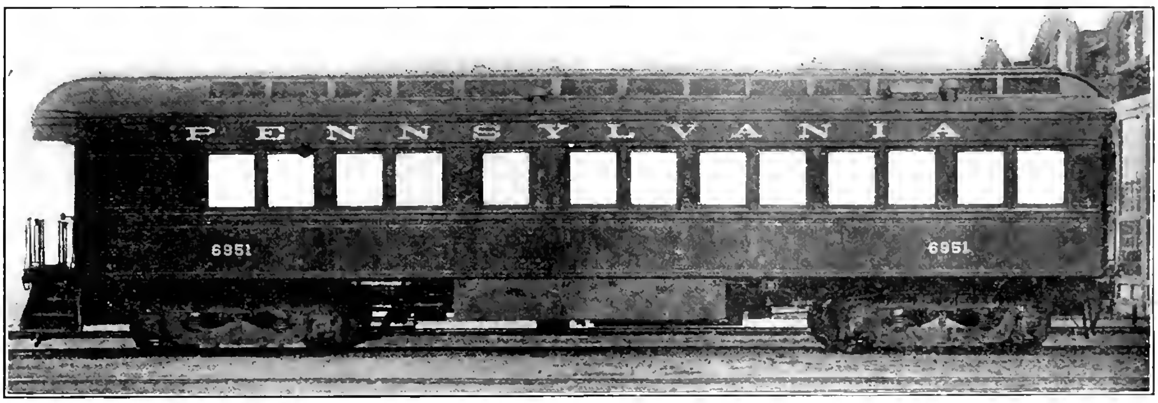
Pennsylvania Railroad.

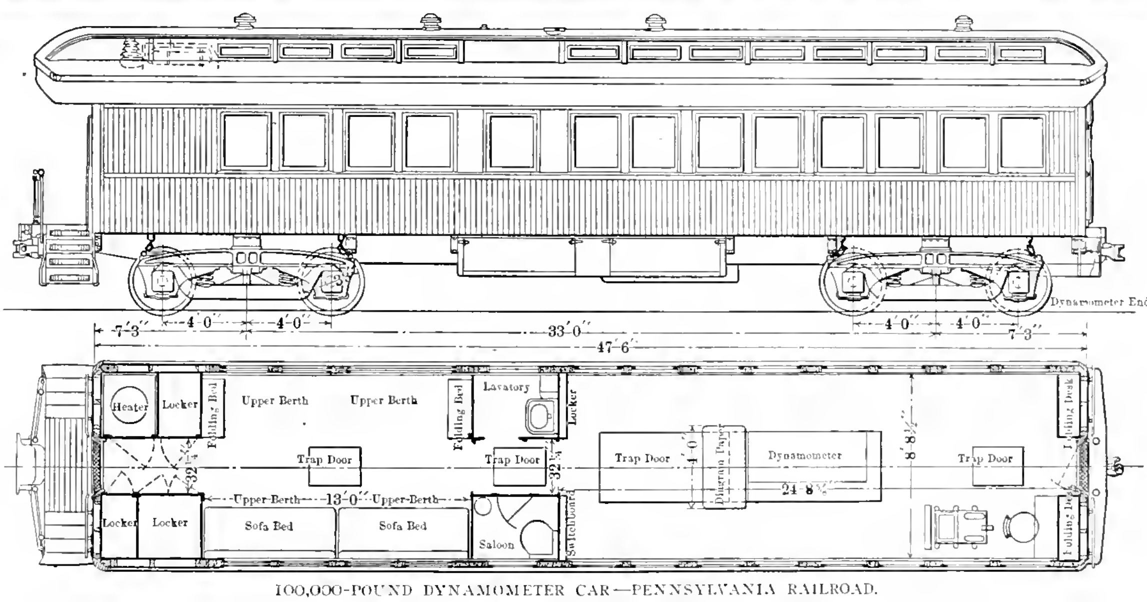
The Pennsylvania Railroad has recently completed a new dynamometer car which, in its construction and working, embodies the result of many years of tests and experiment, and is undoubtedly the best car of its type that has ever been built in this country.

This makes the fifth dynamometer car which the Pennsylvania Railroad has constructed, the earlier three of which were simple and crude affairs compared to the later cars. The fourth car, built in 1885, had a capacity of 28,000 lbs., and has been the means of obtaining a vast amount of very valuable information during its 22 years service. It, however, is altogether too light for modern trains, and the later car has been given a capacity of 100,000 lbs.

The dynamometer complete, with all its attachments, was designed, built and will be patented by Mr. A. H. Emery, of Stamford, Conn., who also constructed the dynamometer used in the former car. The car body complete, as well as the paper driving mechanism and other recording apparatus outside of the dynamometer, was designed and built at Altoona. The specifications for the dynamometer called for a maximum capacity of 100,000 lbs. and a maximum movement of the recording pen of 10 in., the motion to be in the same direction from the base line for either push or pull, and the apparatus to be adjustable so that the value of one inch of motion of the pen could be made to be either 1,000, 2,000, 3,000, 4,000, 5,000, 6,000, 7,000, 8,000 or 10,000 lbs.

After considering several different systems for the dynamometer it was finally decided to use the hydraulic principle in which all of the load on the drawbar should be transmitted directly to the piston of a large hydraulic cylinder secured to the frame of the car. The pressure exerted by this piston on the fluid in the cylinder to be carried to the piston of a small recording cylinder, the movement of which is restricted by a number of carefully calibrated helical springs. The strength of each set of springs will determine the amount of movement of the recording pen secured to the end of the piston rod of the small cylinder, for any pressure exerted on the large hydraulic cylinder or main press. Thus by knowing the relative areas of the two pistons and the amount that the springs will compress under a certain load, the load on the drawbar corresponding to the movement of the recording pen can easily be determined.





100,000-POUND DYNAMOMETER CAR—PENNSYLVANIA RAILROAD.

Taking up first the general construction of the car body. Reference to the illustrations will show its general exterior and interior appearance. It is built with a platform at one end, the opposite end, which carries the drawbar connected to the dynamometer, being built blind. The superstructure is much the same as an ordinary wooden passenger coach.

The underframe is made up entirely of steel. The side sills are formed of five inch 17.9 pounds "Z" bars attached to the center sills by means of cantilevers. The center sill is built up in the form of a box girder 38¾ in. wide inside, 20 in. deep, and extending the entire length of the car. This sill consists of two

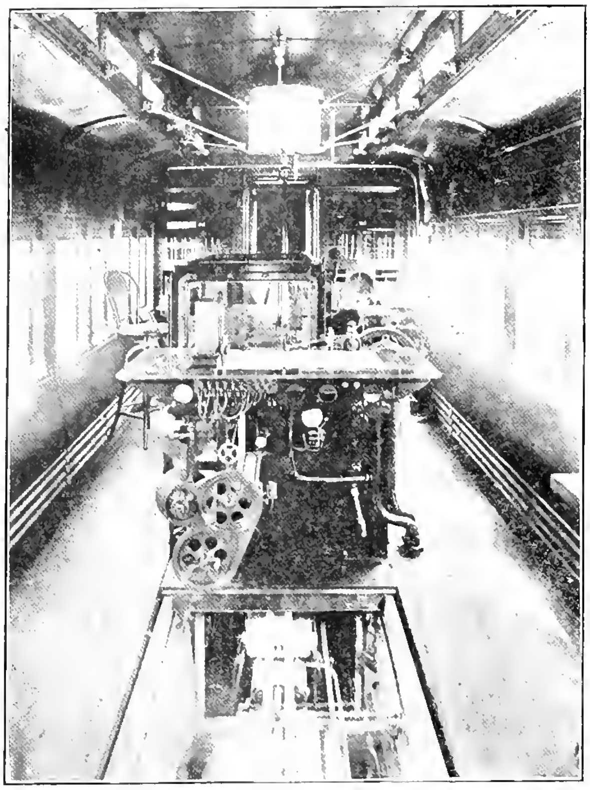


FIG. 3.—INTERIOR OF THE WORKROOM.

20 x ¾ in. plates with ½ in. cover plates top and bottom, the corners being reinforced by 3½ x 3½ x ⅝ in. angles. Within this girder is placed the housing of the main press, which is built up of 1⅜ in. plates securely riveted to the sides of the ¾ in. plates besides being reinforced by three steel castings. This section of the sill has to act as a foundation for all the delicate apparatus in the car, as well as to carry the heavy strains transferred to it by means of the piston rod which passes through the cylinder to the forward end of the car at which place it is attached to the draft gear by means of a heavy cast-steel housing, the details of which are shown in Fig. 8.

The trucks are of special and heavy construction, having an 8 ft. 0 in. wheel base and of a style somewhat like a locomotive truck. The journal boxes are fitted with equalizers, upon which rests double sets of elliptic and helical springs. The truck bolster is pressed steel connected at the ends by means of a transom to the cast steel side frames, to which are also bolted the pedestal jaws. The journal boxes are of a special design, being fitted up with oil trays, which not only carry the oil but support a special lubricating pad held up against the journal by means of two helical springs. The lid is never removed for ordinary oiling, as provisions have been made by an additional opening covered by a small lid, so as to insure a good seal. The axles are fitted with thirty-three inch steel tired wheels, having spoke centers, journals being 5½ x 10 in.

The forward wheels of the rear truck, figuring the dynamometer end as the front end of the car, are of special design, and are not equipped with brake rigging. These wheels drive the paper mechanism, and for that reason they have been very carefully and accurately turned with a straight tread. When it is considered that a slight change in the diameter of these wheels

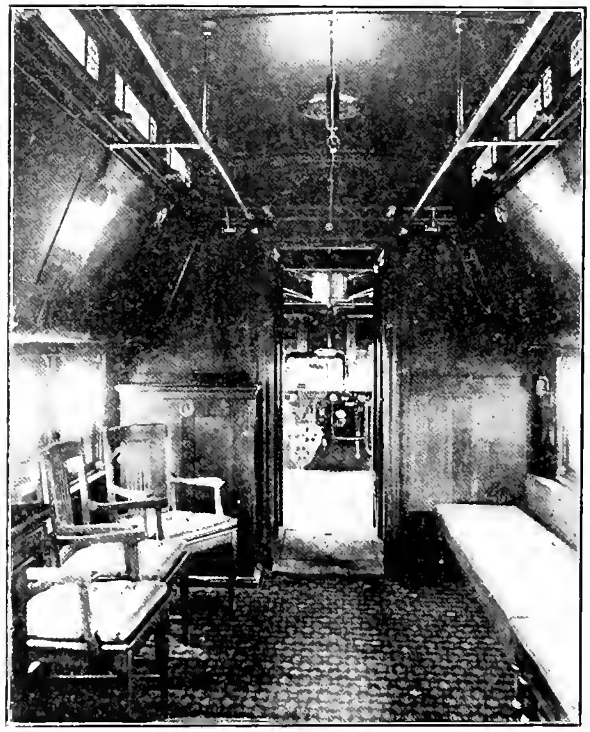


FIG. 4.—INTERIOR OF THE LIVING ROOM.

will make a very large difference in the number of revolutions they make in a 10-mile distance, and hence in the movement of the paper below the recording pen, it is easily understood why special care should be given at this point, and why the tread is made straight instead of coned.

The interior of the car is divided into two main compartments, the larger of which, at the forward end, is known as the workroom and the other, which is directly back of it, being separated by the lavatories, is known as the living room. Back of the latter is a short aisle on one side of which is a heater and a large closet for supplies, and on the other a compartment for coal, oil, etc., ahead of which is a space for a case in which the recording springs of the dynamometer are kept immersed in oil when not in use. The living room, which is 13 ft. 0 in. long, contains four upper berths, two sofa beds, and two cabinet beds, also several chairs and a table, which can be taken apart and stored underneath a berth. It is in this room that the results of the runs can be worked up or the room can be used as a dining-room, there being electric cooking utensils provided in the car. It also can, of course, be used as sleeping quarters, the accommodations being suitable for a crew of eight men. In the workroom, which is 24 ft. 8 in. long, is contained the weighing and recording apparatus, located in the center of the room; a direct con-

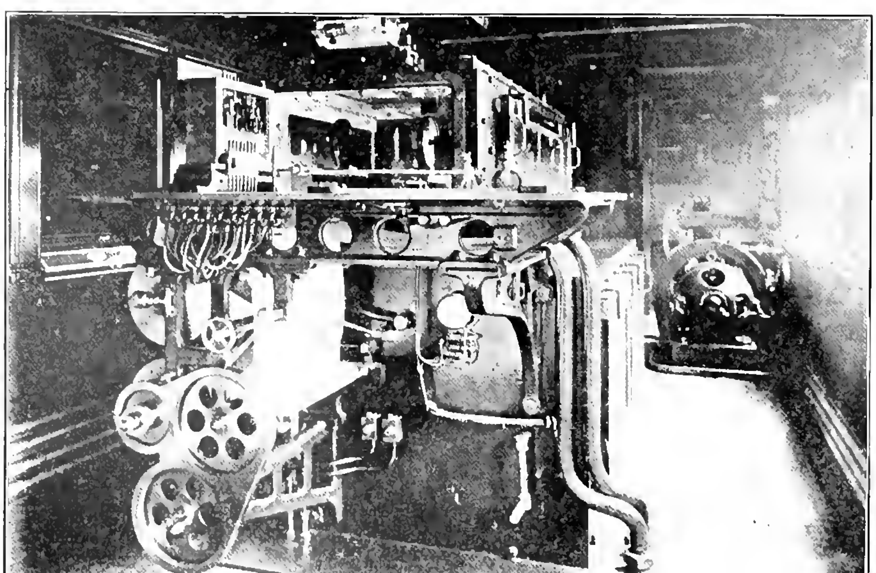


FIG. 5.—VIEW OF RECORDING TABLE AND PAPER DRIVING ROLL.

nected 2½ h.p. oil engine generator set; two folding desks, switchboard and tool cabinets, etc. The photographic illustrations will show the appearance of these different rooms.

The car is lighted by electricity, a storage battery of 32 cells located beneath the car being provided for this purpose. This battery can be charged from the direct connected set on the car when other means are not available. All of the small closets in the car are provided with electric lights, which are turned on by the opening of the doors. A number of plugs are also provided for portable lights. The Thrumveller heating system has been installed and provision is also made for connection to steam from the locomotive or from steam lines in the yard. No provision is made for a cupola or elevated lookout window, such as is usually provided in cars of this type, and the exterior observations are made through a glass shield which can be fitted to any of the side windows, and permits the observer to have a clear view ahead.

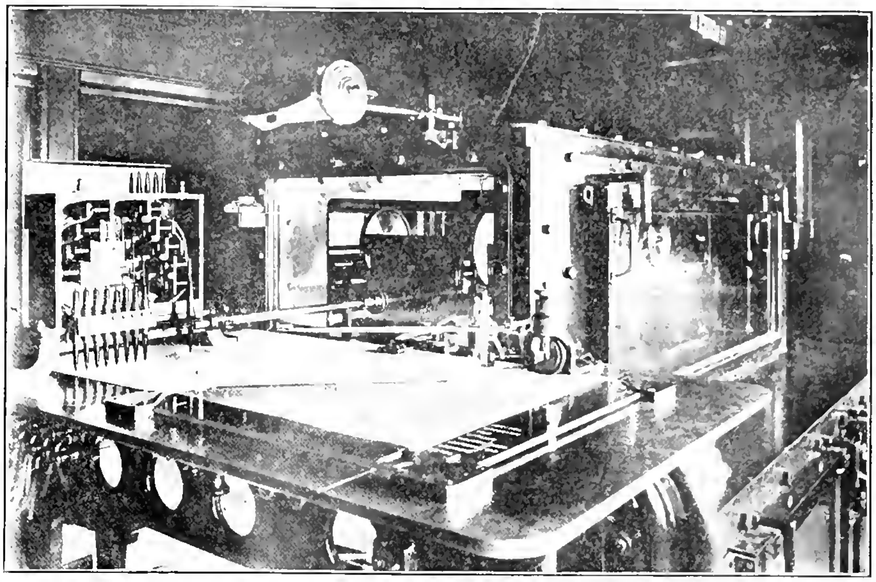


FIG. 7.—VIEW OF TABLE SHOWING RECORDING PENS.

The car measures 47 ft. 6 in. over end sills and weighs about 62 tons complete in working order. The interior finishing and furniture are specially noticeable for their richness and simplicity.

Paper Driving Mechanism.—The paper mechanism is driven, as mentioned above, from the forward axle of the rear truck. This axle was specially made and contains at its center a spiral gear which is integral with it. This gear meshes with a similar spiral gear keyed to a horizontal shaft, which runs forward a distance of about 21 ft., where it ends in a bevel gear. Here the motion is carried to a vertical shaft projecting up into the case beneath the case containing the recording apparatus. On the upper end of this vertical shaft is another bevel gear, which meshes with two gears running freely on a horizontal shaft, which will be seen in Fig. 5 projecting through the end of the case and geared to the paper driving roll. On this shaft and splined to it between the two bevel gears is a collar provided with teeth which can mesh with corresponding teeth in the hub

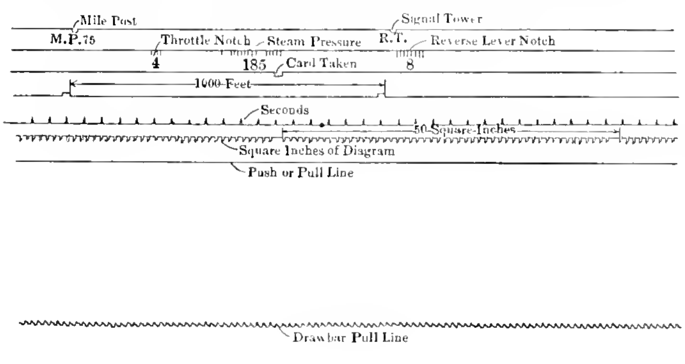


FIG. 6.—SAMPLE RECORD FROM DYNAMOMETER.

of either gear. The movement of this collar is controlled by a handle under the recording table. The adjustment is such that both gears can run free on the shaft or the splined sleeve can be meshed with either so as to drive the paper only in one direction no matter which way the car is running. The paper is carried in large rolls, the supply roll being the upper one in Fig. 5. From this the paper goes up through a slit in the table over the top and below the recording pens, and then down through a second slit in the far end, under a guide roll back underneath the table and then down vertically through the driving roll and to the receiving roll, which is friction driven and always moves fast enough to keep the paper tight. The driving roll is of bronze, with its surface slightly roughened, and has its diameter so proportioned to the diameter of the car wheels that the paper moves across the record table at the exact rate of 1 in. per 100 ft. travel of the car. A rubber roll presses the paper firmly against the driving roll, so that no slip can occur.

Fig. 6 gives a sample record which is reversed in position from the location of the paper as shown in the view of the recording table, Fig. 7. The lower, or datum, line, is made by a small wheel with its circumference in contact with an inking pad, which revolves in the opposite direction of the motion of the paper, as the paper passes beneath it. Above this is the record of the drawbar pull made by the pen on the end of the piston rod from the recording cylinder. This will be seen projecting out through the front of the glass case. Above this is the record of a pen which automatically shows whether the load on the drawbar is a push or a pull. Since the dynamometer is arranged to register on the same side of the datum line for both it is impossible to tell from the record line whether the load is forward or backward. The next record is from the mechanical integrator, the arm of which is connected to the recording pen. An electrical connection is made to the integrator wheel on the table, so that every notch in the record has a value of 1 sq. in. of area between the dynamometer record and the base line. Every fiftieth notch is skipped, so that the numbers can be quickly summed up. Since the integrator wheel usually stands at an angle to the motion of the paper it has a tendency to cause the paper to slip sidewise. To correct this an instrument, shown at the right of the integrator wheel in Fig. 7, is provided. This consists of a rubber wheel rolling on the paper, which can be set at any desired angle to counteract the influence of the integrator wheel. Beneath this rubber wheel and set in the face of the table is another wheel, the diameter of which is very carefully made so that it will have one revolution for every 10-in. motion of the paper, and by electrical connection makes a record showing the 1,000 ft. distance traveled by the car, which record is the fourth from the top in Fig. 6. The record directly below this is made by a connection to the chronometer and indicates the distance passed over by the paper at five second intervals. There are three other pens, the records of which are shown in Fig. 6. The third from the top is operated by an observer on the locomotive and records the time of taking indicator cards. The second is also operated from the locomotive and records the steam pressure and the position of the throttle and reverse levers. The upper one is operated by the observer at the lookout window, and is used to record locations of permanent objects, such as mile posts, signal towers, curves, etc. An extra or reserve pen is also provided for use in emergencies.

One corner of the paper is covered by a triangular sheet of glass, on which the operator can rest his arm while making notes without any danger of impeding the motion of the paper.

The Dynamometer.—As mentioned above, the load from the

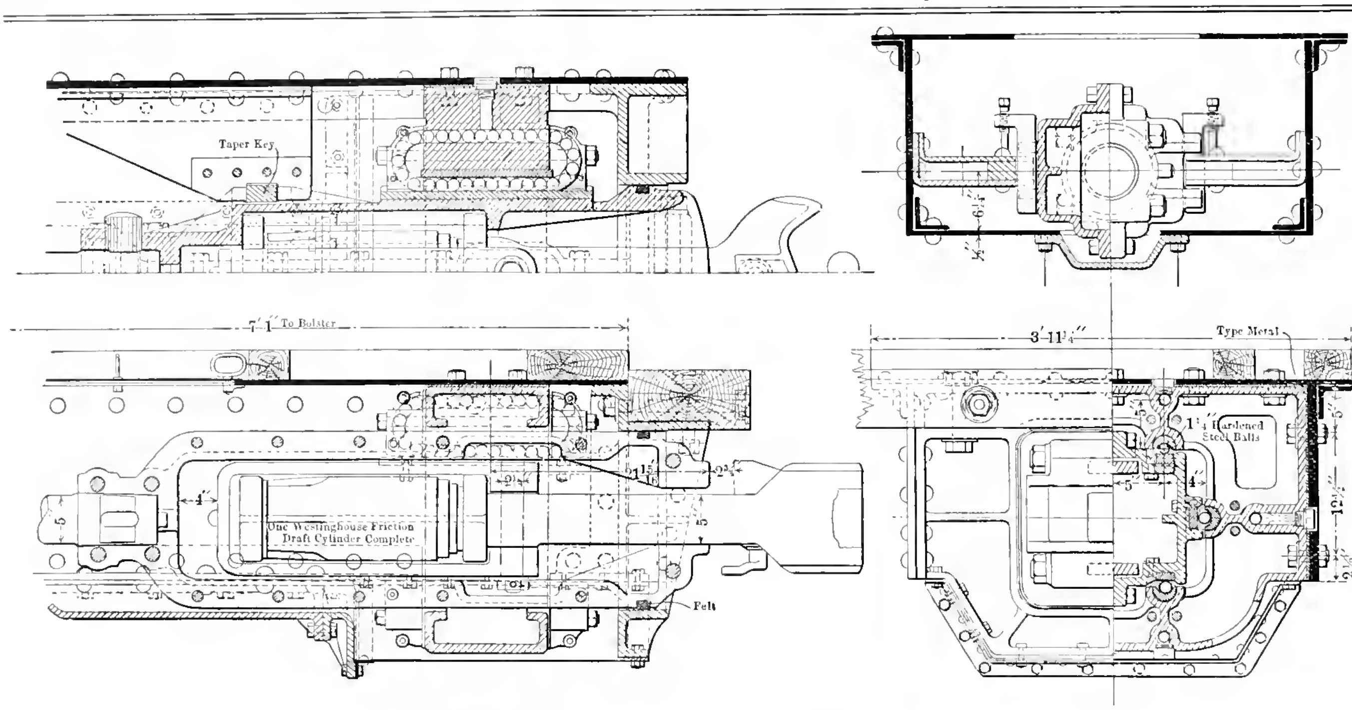


FIG. 8.—DRAFT GEAR HOUSING AND END OF CENTER SILL—PENNSYLVANIA R. R. DYNAMOMETER CAR.

drawbar is transmitted directly to the piston of the main press, and since it is desirable to get a very accurate measurement of the exact load on the drawbar, it is necessary to use all possible care in eliminating friction between the coupler and the piston. This has been done by the liberal use of a ball and roller bearing at all points of support, and in addition special arrangement has been made to keep all dust and dirt from getting access to the interior of the box girder center sills wherein the connections lie.

The coupler head is connected to a Westinghouse friction draft gear by the usual yoke. This draft gear is secured within a heavy cast steel housing, the details of which are shown in Fig. 8. This housing is carried in a frame which forms part of the center sill construction, and is supported and guided in it by a set of six circuitous ball bearings, each containing 32 hardened steel balls 1¼ in. in diameter. The bearings, or ball races, are so arranged as to have 10 of these balls constantly in contact with the housing, thus holding it in rigid alignment and practically without friction. The space between the outer end of the housing and its frame is fitted with a felt bushing. To relieve the dynamometer mechanism from all load when it is not in use provision is made for the inserting of tapered keys between lugs on the housing and its frame, so that they are rigidly held together and the load is carried directly to the sills in the usual manner.

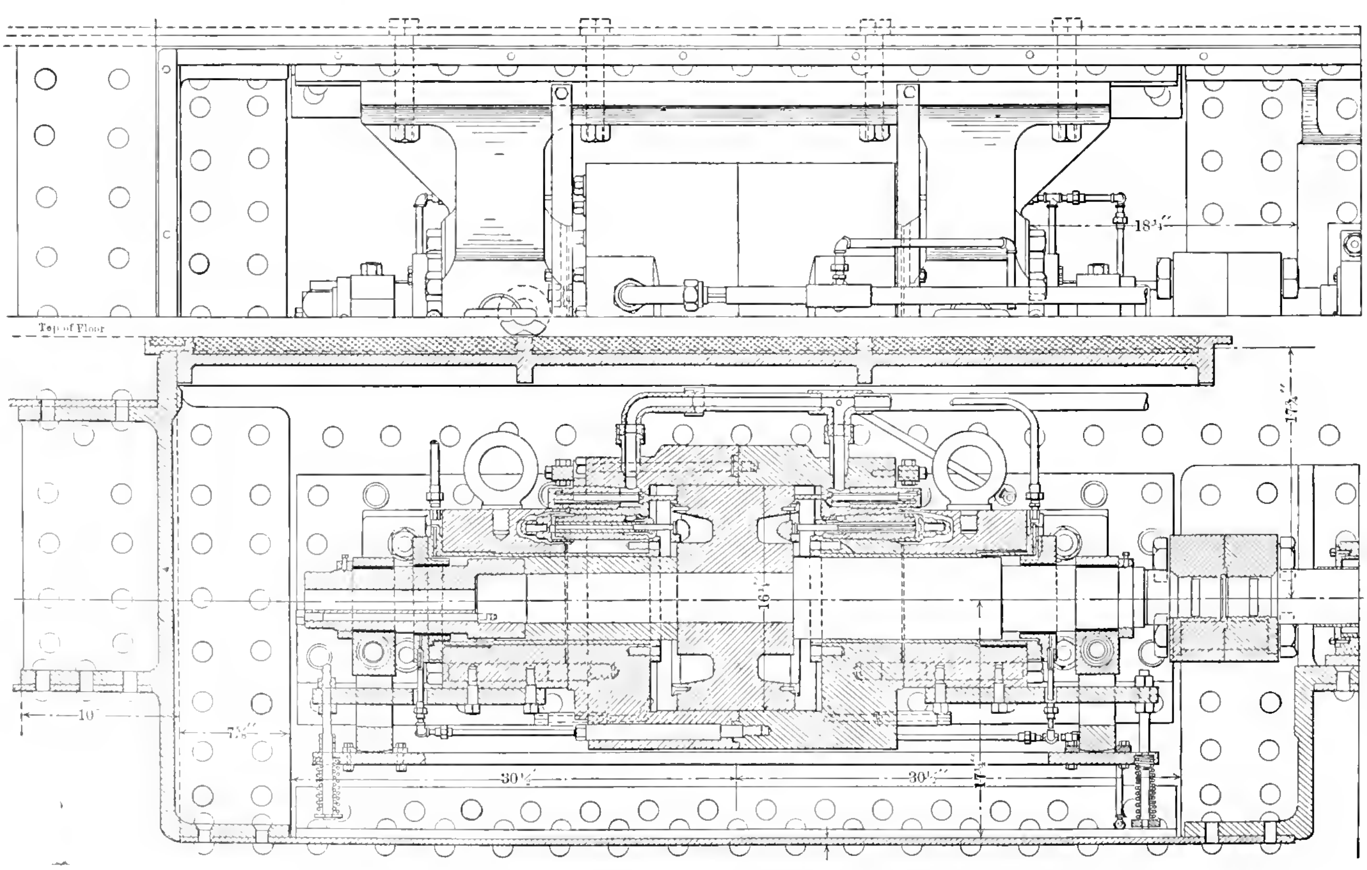
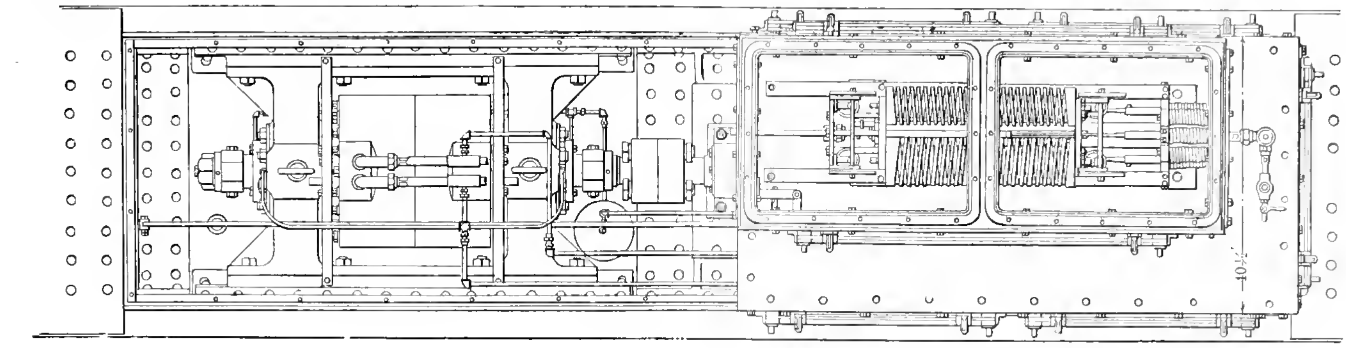


FIG. 9.—DYNAMOMETER CYLINDER OR MAIN PRESS—PENNSYLVANIA RAILROAD DYNAMOMETER CAR.



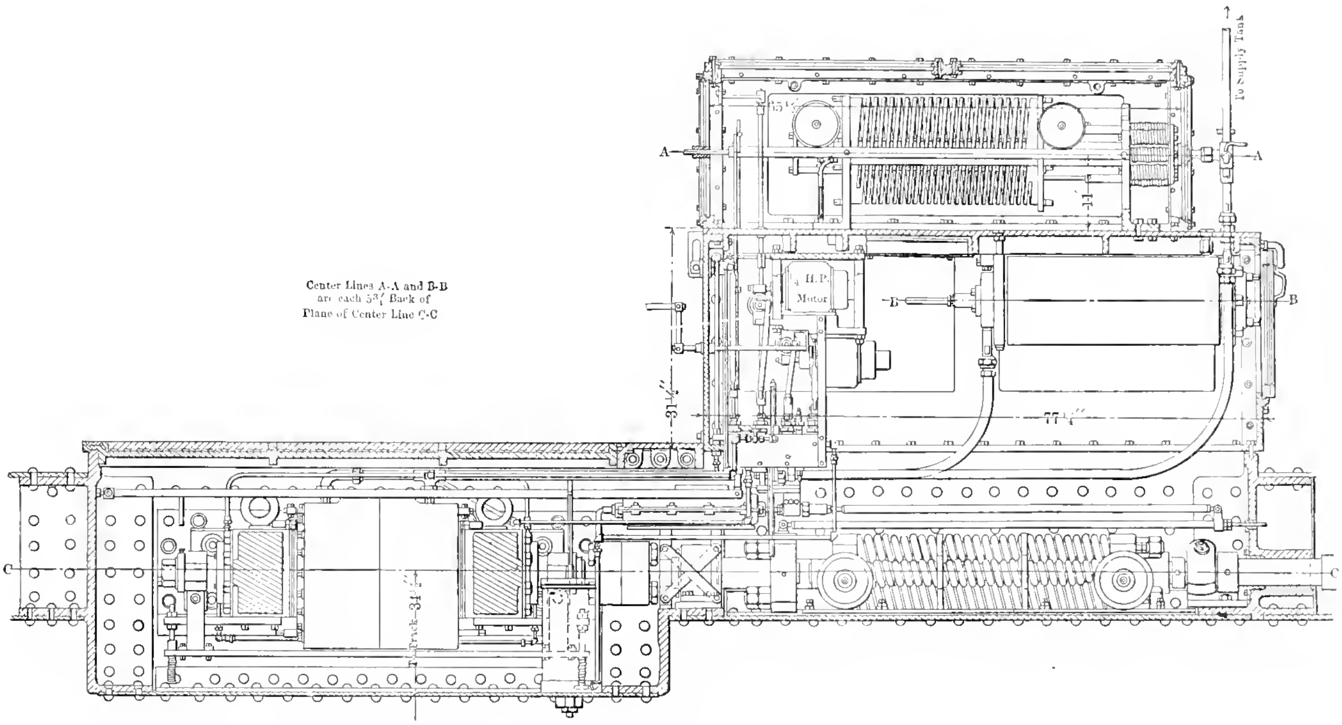


FIG. 10.—MAIN PRESS, RECORDING CYLINDER AND CONNECTIONS—PENNSYLVANIA RAILROAD DYNAMOMETER CAR.

The rear end of the housing is connected to a shaft or drawbar which about 6 ft. back passes through a cast-steel partition in which is placed a special form of stuffing box that is practically frictionless, and beyond which it connects to a spring buffer. This spring buffer is designed to take all loads above 100,000 lbs., the capacity of the apparatus. It consists of three cross heads, one being permanently fixed to the extension of the piston rod from the main press of the dynamometer, while the other two crossheads fit around the drawbar shaft and are held in place by nuts on the outer side of each. Four long bolts pass through all three crossheads and are secured in the one from the main press and are movable in the other two. There are distance or spacing thimbles around the bolts between the first and second crosshead at the left. Coil springs are fitted around the bolts between the two crossheads at the right, and by means of nuts on the ends of the bolts these springs are set with a compression of 100,000 lbs. The whole apparatus is carried on a small carriage fitted with four wheels, as is shown in the illustration. Since the springs are under compression of 100,000 lbs. all loads up to that limit will be transmitted directly through the buffer the same as if it were a solid bar. If the load increases above this, one crosshead will move away from the thimbles and the springs will compress until they have shut 1⅛" less whatever the piston has moved from the central position, when a stop on the drawbar shaft will strike against the partition just to the right of the buffer and then any load over that necessary to compress the springs this much will be transmitted directly to the frame of the car. The same action takes place for either pulling or buffing strains.

To minimize the friction, the weight of the draft gear and its connecting rod to the piston of the main press cylinder, is carried on frictionless bearings either in the form of rockers which rotate on ball bearings or else it is carried on ball bearings with straight race-ways. That part of the box girder which contains the main press is made absolutely dust proof. Provisions have also been made to keep this compartment at as nearly a uniform temperature as possible, both winter and summer, so that a minimum variation in the viscosity of the oil will be obtained.

Fig. 9 shows the details of the main press and Fig. 10 illustrates its connections to the recording cylinder. The construction will be seen to be very heavy and since it is necessary to eliminate friction as far as possible and as the leakage allowance is very small, it is necessary to make some provision for carrying the weight of the piston and its rod so as to prevent wear of the bushings in the end of the cylinder and allow a close fit without friction. This has been done by means of a support at either end outside of the cylinder, consisting of rocker arms bearing on a flat support which is carried by four springs from the main cylinder housing. The rocker arms at their upper ends carry a cross shaft fitted with roller bearings on which the piston rod rests. By adjustment of the springs supporting the carrying plate it is possible to just relieve the weight of the piston from the bushings.

The piston itself is 16¼ in. in diameter and is 8 in. long. It is carefully fitted to the cylinder and is grooved with a spiral groove on its periphery to secure lubrication and avoid the use of packing. The cylinder itself is made of gun iron in two parts fitted together as shown in the illustration.

Since it is necessary for the dynamometer to register in either

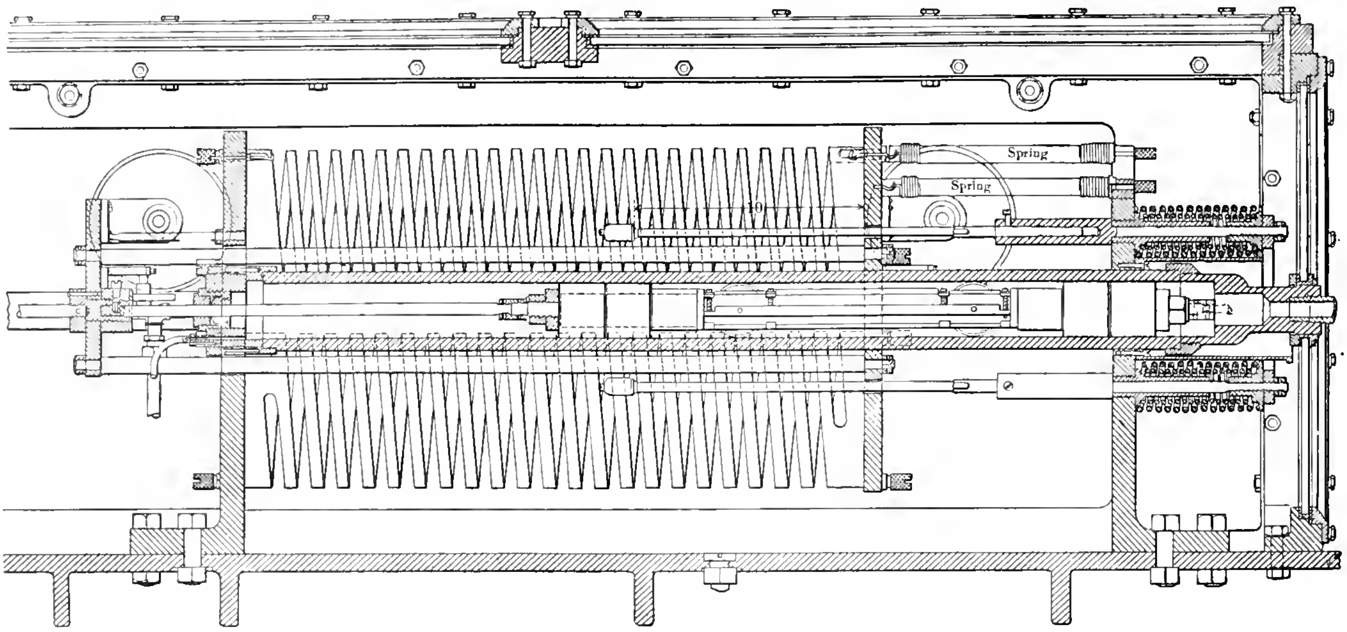


FIG. 11.—DETAILS OF RECORDING CYLINDER—PENNSYLVANIA RAILROAD DYNAMOMETER CAR.

direction, automatic valves have been arranged so that when the piston is in the exact center the valves leading to the recording cylinder and the supply tank are both slightly open and the whole apparatus is in equilibrium. A slight movement in either direction, however, will close the valve to the supply tank on the side toward which the piston moves and open the valve leading to the recording cylinder, while on the opposite side the reverse takes place, thus while either side of the piston is compressing the liquid into the recording cylinder the other is always open to the pressure from the supply tank.

Fig. 11 shows a cross section of the recording cylinder and Fig. 12 is a view of this cylinder with the springs in place, and also shows the recording piston with its rod and carriage on the table in the foreground. The recording cylinder, which is connected by an oil pipe at the back end through the cooling cylinder directly to the main press, is 40 in. long and 2 17/32 in. in diameter. It has a piston area equal to about 1/36 of that of the main press. Since it is even more necessary to eliminate friction at this point than in the main press extreme care has been taken in the design of the piston and cylinders so as to allow perfectly free movement and to prevent all possible wear while at the same time making the leakage so small as to be negligible. For this purpose four pistons are provided in pairs, each pair being fastened to the end of a long arbor. This arbor is provided with a pair of rollers whose axles are carried in two side bars, thus forming a small truck which carries the arbor and piston. Eight springs which are interposed between the wheels and the truck can be accurately adjusted so as to just support the weight of the moving parts. The ends of the recording cylinder are supported by plates, which also carry two rectangular bars, forming a track for a four-wheel truck. Extending from the arbor carrying the piston is a small piston rod, which connects to a crosshead forming the forward end of the truck just mentioned. The rear end of this truck is formed by another crosshead, the connection between the two being made by four rods, which pass freely through openings in the forward stanchion supporting the recording cylinder. The recording springs are placed between the rear crosshead of the truck and this front stanchion. The piston rod is carried on beyond the crosshead and through the glass case which encloses all of this apparatus and on its end carries the pen for making the record. The recording springs are fastened in place by thumb screws and are of special construction, which will be mentioned later.

In order to prevent any possibility of accident to the recording springs in case too light springs are in place for the load on the main press, a spring buffing arrangement is attached back of the rear stanchion, and so connected as to come into action when the carriage has made a movement of 10 in., the limit of travel of the pen. Springs are used for this purpose in place of solid stops, because of the possibility of the throttling device between the main press and the recording cylinder being left open when light springs were in place and a sudden load which might come upon the machine would then force the piston out very rapidly and make it inadvisable to bring it against a solid stop. The construction of this apparatus is clearly shown in the illustration.

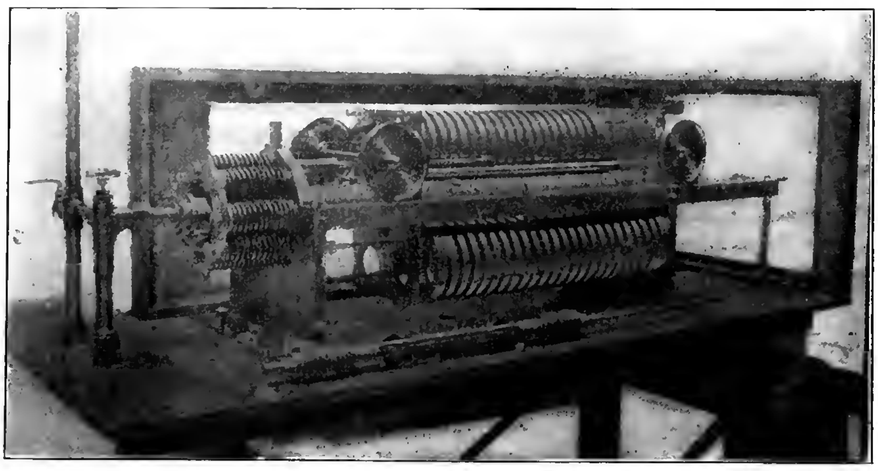


FIG. 12.—VIEW OF RECORDING CYLINDER, SPRINGS AND SPRING BUFFER.

The manufacture of the springs to resist the movement of the recording piston, which must be capable of giving exactly the same movement per increment of load for any point during a compression of 10 in., required a large amount of study and experimentation. After several failures and much tedious labor, the problem was solved by making the springs in the following manner: A drum of nickel steel was rough turned to the desired outside and inside diameter and cut off to the proper length, and was then hardened in an oil bath. After being hardened it was turned and bored to the exact size, carefully fitted to a mandrel and a spiral groove was cut through the drum, starting

near one end and stopping near the other, leaving a spring of square section with solid ends. This was then carefully tested and ground on the outside until it would give exactly the same movement under the same increase of load at any point in a compression of 10 in. for any number of applications. In fact, so accurate was this work that its probable error in 10 in. is only about 1/1000th of an inch. The difficulty attending this work will be understood when it is stated that after the drum was hardened it, in some cases, took two days to drill a 7/16 in. hole ⅝ of an inch deep in the drum. The threading of one drum took 27 working days to finish. There was but one kind of tool steel which was found capable of doing this work and that would only operate when given special heat treatment and required constant sharpening. The springs are 27 in. long and vary from 5.6 to 7.3 in. outside diameter. They weigh from 29.4 to 58.6 lbs. each. The smaller ones, of course, being the ones used for the larger movement of the pen under lighter loads.

For supplying oil to the cylinders and to take care of all leakage past the piston a complete system of tanks, piping and pumps has been provided. The large supply tank, shown near the roof

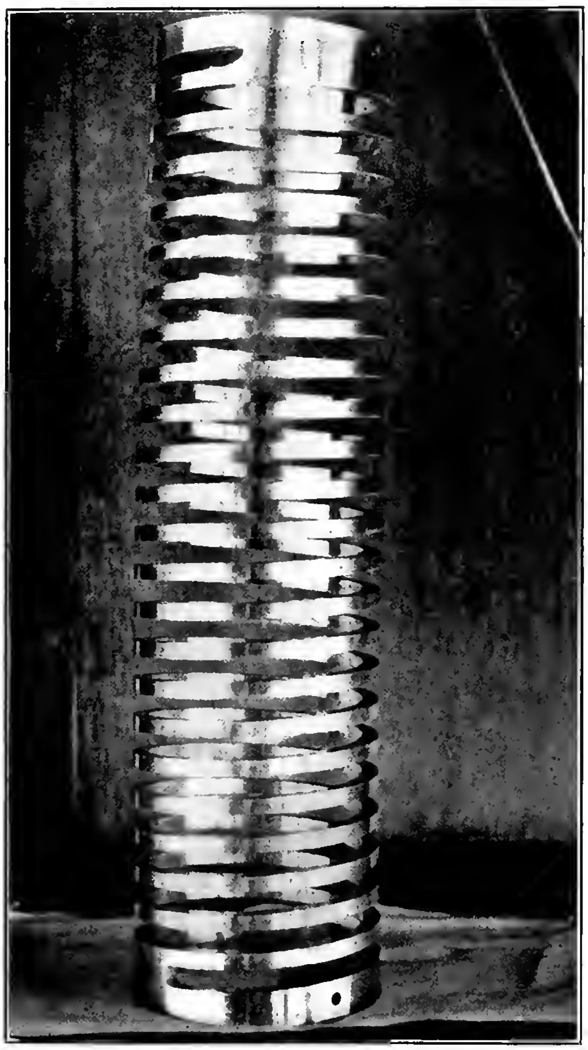


FIG. 13.—ONE OF THE SPRINGS.

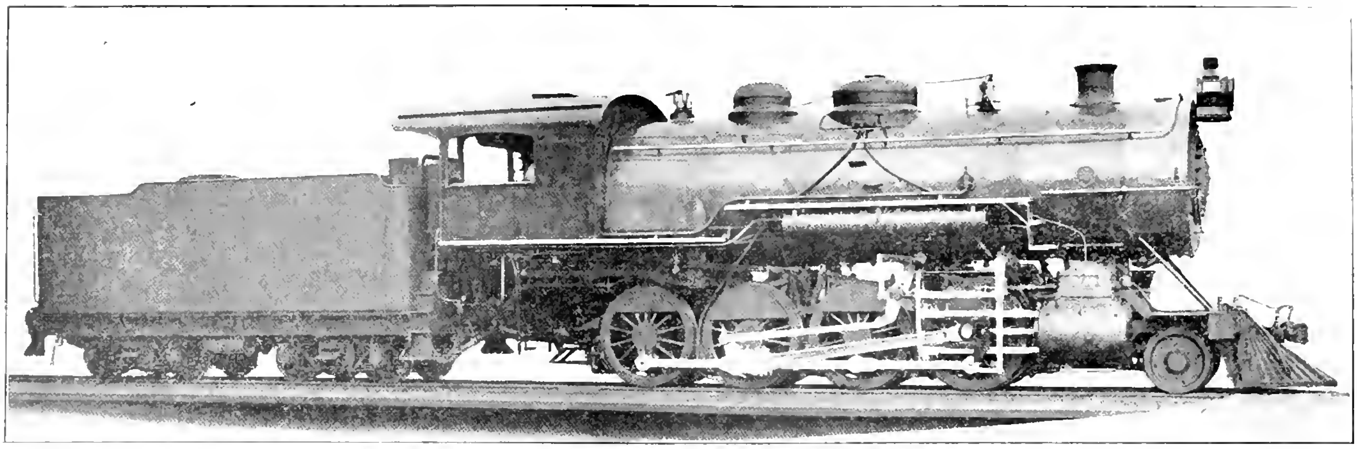
of the car in Fig. 4, is connected directly to the valves in the main press. Interposed between the main press and the recording cylinder is a cooling cylinder on the end of which is a needle valve which can be controlled from the operating table and is used to throttle the passage of the oil to the recording cylinder. If necessary, this valve can be closed, thus cutting off the recording mechanism altogether.

The leakage past the piston of the recording cylinder, as well as that through the piston rod glands of the main press, is conducted through a system of pipes to the leakage tank, which is fitted with a float valve, and upon the oil reaching a predetermined level this closes the circuit and starts a motor driven pump which returns the excess leakage to the supply tank. If on account of leakage past the main piston or for any other reason this piston leaves the center line of the cylinder more than ⅝ of an inch another electrically driven pump is started, which will force the piston back to within ⅝" of mid-position, being capable of working against the maximum pressure exerted by the main press. Both of the electrical pumps are supplemented by hand pumps, and there is an electrical alarm which sounds when anything goes wrong with the electrical pump.

AVERAGE LOAD IN BOX CARS.—It is a question whether railroads exercise their best judgment in building their equipment upon the single basis of carrying capacity instead of on the double basis of cars and carrying capacity. Too many high-capacity cars have been built in recent years, as shown by the small average load; and in view of the fact that there have been relatively few changes in classification. In order to demonstrate the truthfulness of this as relates to box cars, some figures were prepared covering the business of the busiest months of the Erie Railway, and it was found that, exclusive of merchandise, the average load placed in a 60,000-lb. car was 15 tons; in a 70,000-lb. car, 21 tons; in an 80,000-lb. car, 21½ tons.

It will be noted that the average load would utilize less than half of the carrying capacity of the 40-ton box car, and about two-thirds carrying capacity of the 30-ton box car. During the last fiscal year, the Erie Railway handled 1,120,000 loaded box cars. Of this number 470,000 were loaded with merchandise, which averaged 12,000 lbs. a car, and 650,000 were loaded with freight other than merchandise, which averaged 41,000 lbs. If the Erie Railway could have had its choice of 30-ton cars or 40-ton cars, in which to handle all freight requiring box cars, during the last fiscal year, a saving of $312,000 would have been effected in the cost of operation by the use of the smaller car, the lesser weight of the smaller car making this possible. Heavy capacity cars are operated economically when used for handling specified commodities of great specific gravity, such as tidewater coal and ore.—*Mr. C. C. Riley before the New York Traffic Club.*

POWER FACTOR IN RAILROAD SHOPS.—The percentage of generator capacity to the sum of the rated motor horse-powers is somewhat uncertain, but it is lower perhaps than generally imagined. At the 1903 convention of the Master Mechanics' Association a committee reporting on electrically driven shops stated that 40 per cent. of the aggregate horse-power of the tools could be taken, and to this added the constant and average lighting load in order to determine the capacity of the generators required, without including in the list of such motors those required for cranes, transfer tables or turntables, but that the question of a spare unit should always receive consideration. The Master Mechanics' proceedings for 1900 stated that at the Baldwin Locomotive Works, the switchboard load averaged only about 27 per cent. of the total motor rating, in this case the crane motors being included. At the Topeka shops a switchboard load equal to 38 per cent. of the various motors, exclusive of those on the cranes, was found to obtain. At the McKee's Rocks shop the power consumption was about 30 per cent. of the motor rating. The actual installation of some large and modern shops is very interesting. At Collinwood the total generator capacity (after deducting requirements for lights) was 50 per cent. of the sum of the motor ratings, not counting those upon the cranes. At McKee's Rocks shop it was 47 per cent. on the same basis; at the Angus shop, Montreal, 37 per cent. The new Parsons shop of the M. K. & T. Ry. has a generator capacity of about 75 per cent. of the total rated motor capacity. Of course the question of the size of generators and also spare units affects this to a certain extent, and the best way to study the question is to lay out a hypothetical load diagram and determine from this the most economical size of units.—*Mr. G. R. Henderson at the New England Railroad Club.*



SIMPLE CONSOLIDATION LOCOMOTIVE WITH BALDWIN SUPERHEATER.

SIMPLE CONSOLIDATION LOCOMOTIVE

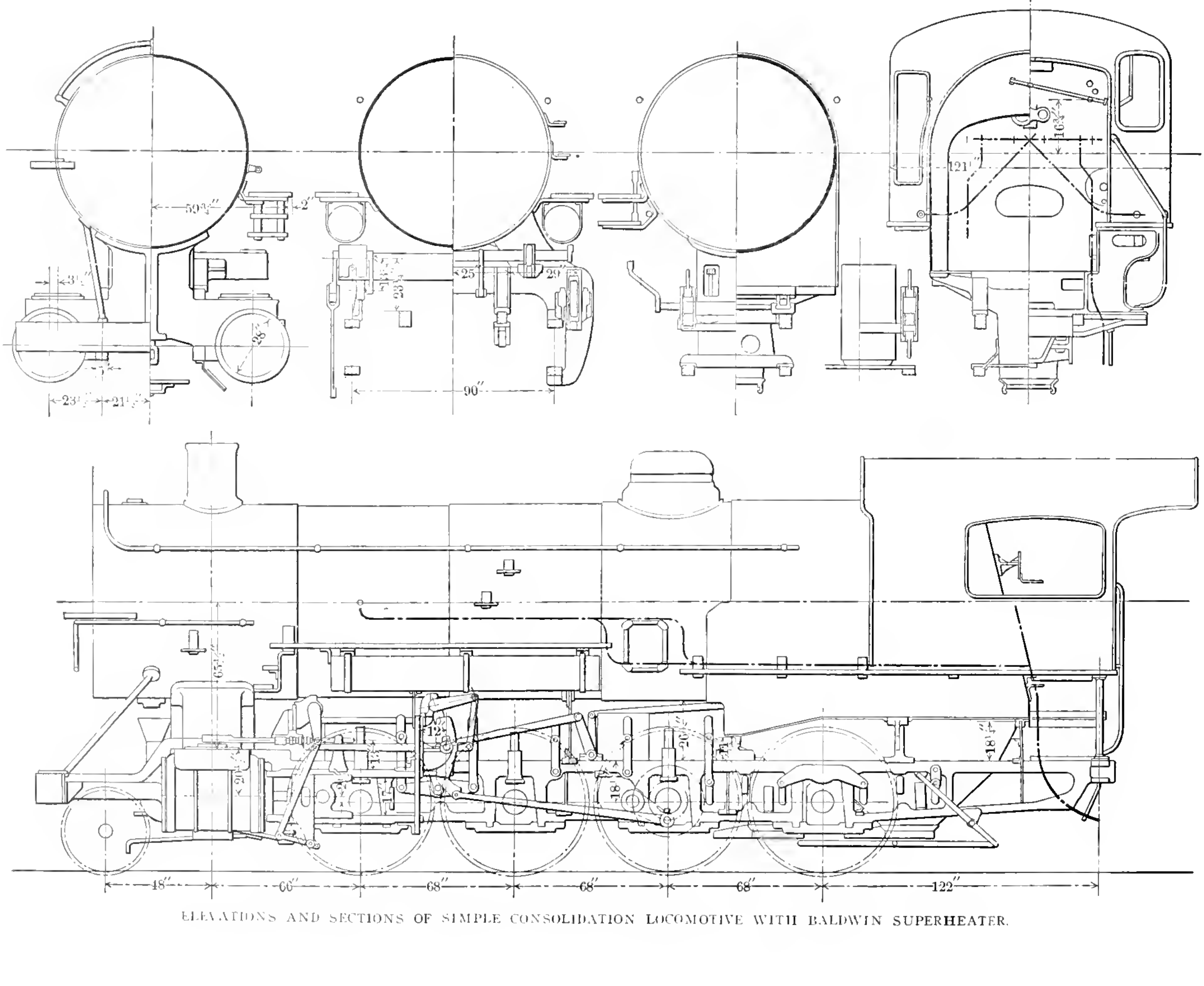
FITTED WITH BALDWIN SUPERHEATER.

The Baldwin Locomotive Works has recently completed a very interesting simple consolidation locomotive which will form part of its exhibit at the Jamestown Exhibition.

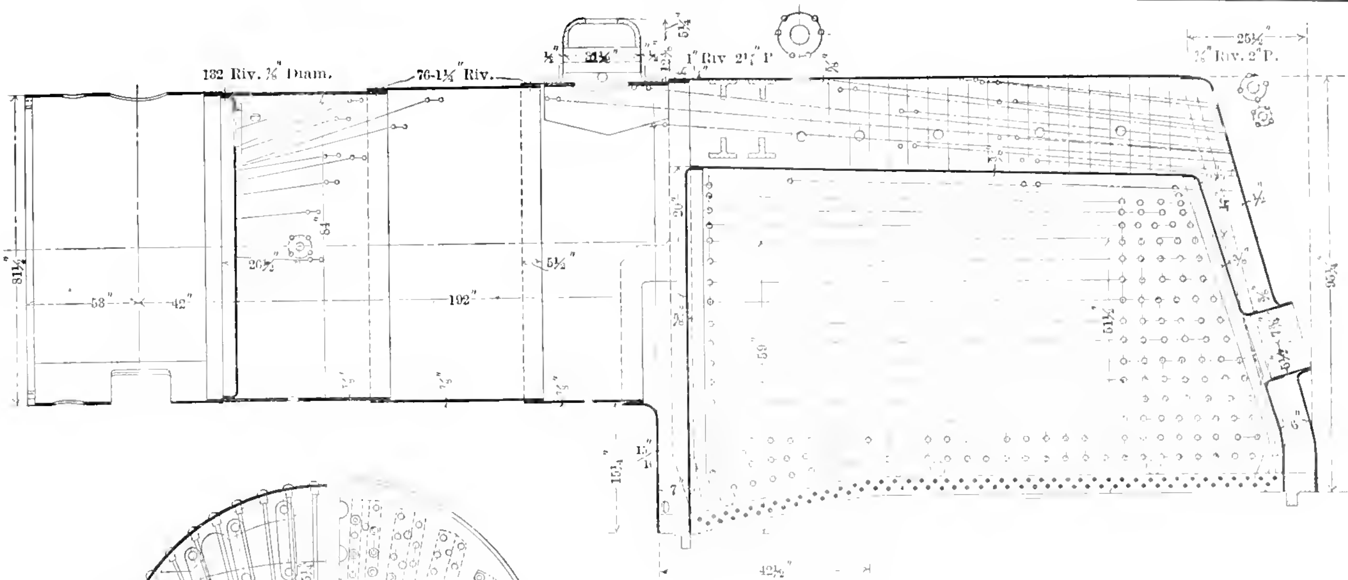
This is the heaviest locomotive of its type ever built, and shares with the Santa Fe type, recently built by the same company for the Pittsburg, Shawmut & Northern Railway,* the distinction of having the largest simple cylinders ever applied to a locomotive. Like that locomotive also it carries but 160 lbs. steam pressure, and is fitted with the Baldwin design of smoke-box superheater. The boiler is 84 in. diameter at the front end and has 472 2-in. flues, making it one of the largest ever applied to a locomotive of any type designed for regular road service.

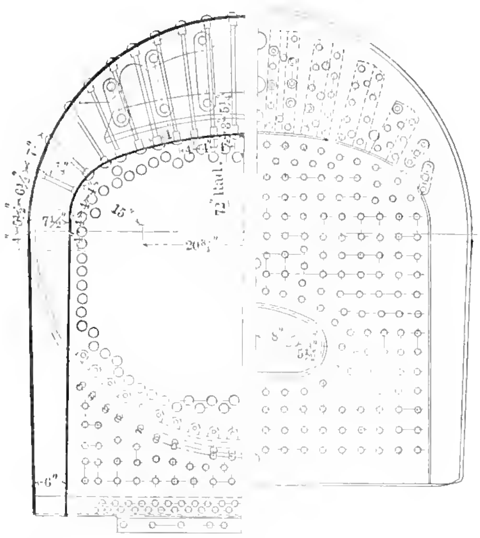
The locomotive weighs 260,1000 lbs, of which 232,700 lbs., or 89 per cent., is on the drivers. This gives a weight of 58,175 lbs. per axle, which we believe is the greatest weight ever put on one pair of locomotive driving wheels. The main journals are 11 x 12 in., and the others are 10 x 12 in. The next heaviest locomotive of this type on our records is the one on the P., B. & L. E., built in 1900, which weighs 250,300 lbs. total, and 225,200 lbs. on drivers, giving a weight of 56,300 lbs. per axle. The main journals are 10 x 13 in., the others being 9 x 13 in. This is followed by those on the Delaware and Hudson Company's line (AMERICAN ENGINEER, January, 1907, page 22), which weighs

* See AMERICAN ENGINEER AND RAILROAD JOURNAL, March, 1907, p. 88.



ELEVATIONS AND SECTIONS OF SIMPLE CONSOLIDATION LOCOMOTIVE WITH BALDWIN SUPERHEATER.





BOILER OF BALDWIN CONSOLIDATION LOCOMOTIVE.

246,500 lbs. total, and 217,500 lbs. on drivers, giving a weight of 54,375 lbs. per axle, the journals all being 10 x 12 in.

The cylinder castings, as can be seen in the illustrations, are simple in design, with heavy walls and double bolted flanges. The front frame rails are 5 in., wide, and have keys at the front only. The cylinder diameter is 28 in., and the stroke is 32 in. This is equivalent to a 25 x 32 in. cylinder, with 200 lbs. steam pressure. The increase in area of cylinder walls of the 28 in. over the 25 in. cylinder is 304 sq. in. in each cylinder, or over 12 per cent. With saturated steam this would be a matter requiring careful consideration, but as superheated steam is used in this case the condensation loss from the increased area is probably more than overcome by the reduction in leakage and by the increased amount of superheat which can be given to steam of 160 lbs. pressure (370°) over that at 200 lbs. pressure (389°). To insure adequate lubrication a five-feed lubricator is provided and a separate feed is carried to the pistons, being tapped in at the center of the cylinders.

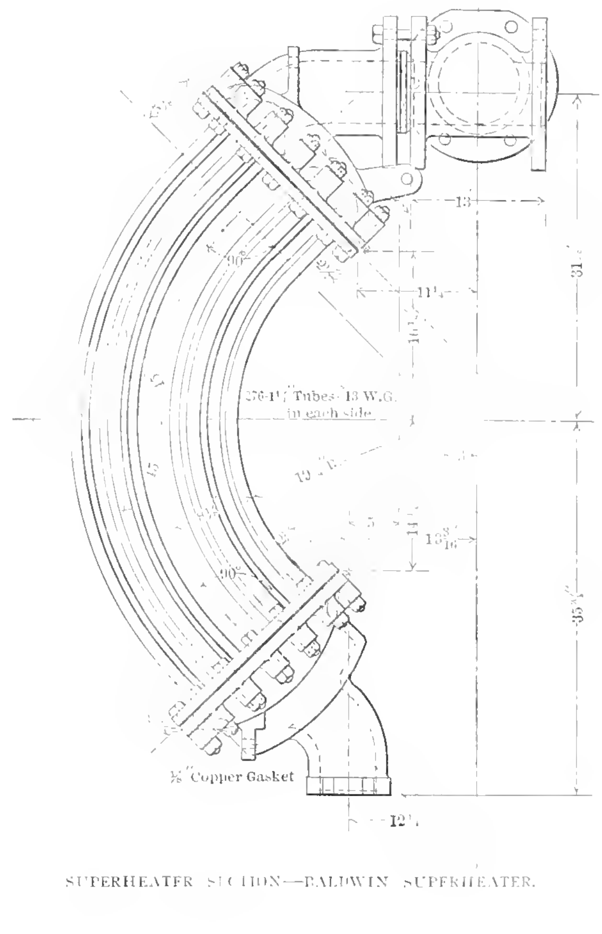
The boiler, as is shown in the illustration, is of the straight type and measures 84 in. diameter at the front end. The firebox is radially stayed and the cast steel mud ring is six inches wide on all sides. The boiler is designed for 200 lbs. pressure, although but 160 lbs. is being carried. There are 472 2-in. flues 16 feet long, which give a heating surface of 3,931 sq. ft. The firebox heating surface of 198 sq. ft. is but 4.8 per cent. of the total.

The main frames are cast steel 5 in. in width throughout and fitted with pedestal binders of the well-known clip design. The equalization system is broken between the second and third pairs of driving wheels. The use of the Walschaert type of valve gear permits a very efficient system of frame bracing.

The valve gear drives the outside admission slide valves through a rock shaft with two arms, the inner connecting to the valve stem and the outer to the combination lever. This permits the valve center to be thrown 3½ in. inside the cylinder centers. The arrangement and design of the valve gear is clearly shown in the illustrations. The M'Carroll air reversing mechanism * is used.

The smokebox superheater fitted to this locomotive is similar in every way to the one used on the Shawmut locomotive mentioned above and reference can be made to the description of that locomotive for the arrangement of this device in the front end. The illustration of one of the sections shown herewith gives an idea of the general construction. It consists of an upper and lower cast steel header on either side, between which are a large number of small steel tubes curved to the contour of the smokebox. These pipes are divided into groups and the passages in the headers are so arranged as to compel the steam in passing to the cylinders to transverse the different groups of superheater pipes and thus be held in contact with the front

* See American Engineer and Railroad Journal, Oct., 1906, p. 375.



SUPERHEATER SECTION—BALDWIN SUPERHEATER.

end gases, which, by the proper arrangement of deflected plates, all pass the superheating tubes as soon as they emerge from the flues; a sufficient length of time to attain a fair degree of superheat. The large size of the front end in this locomotive permits a superheater with 834 sq. ft. of surface to be installed without difficulty. The outside of the front end is heavily lagged.

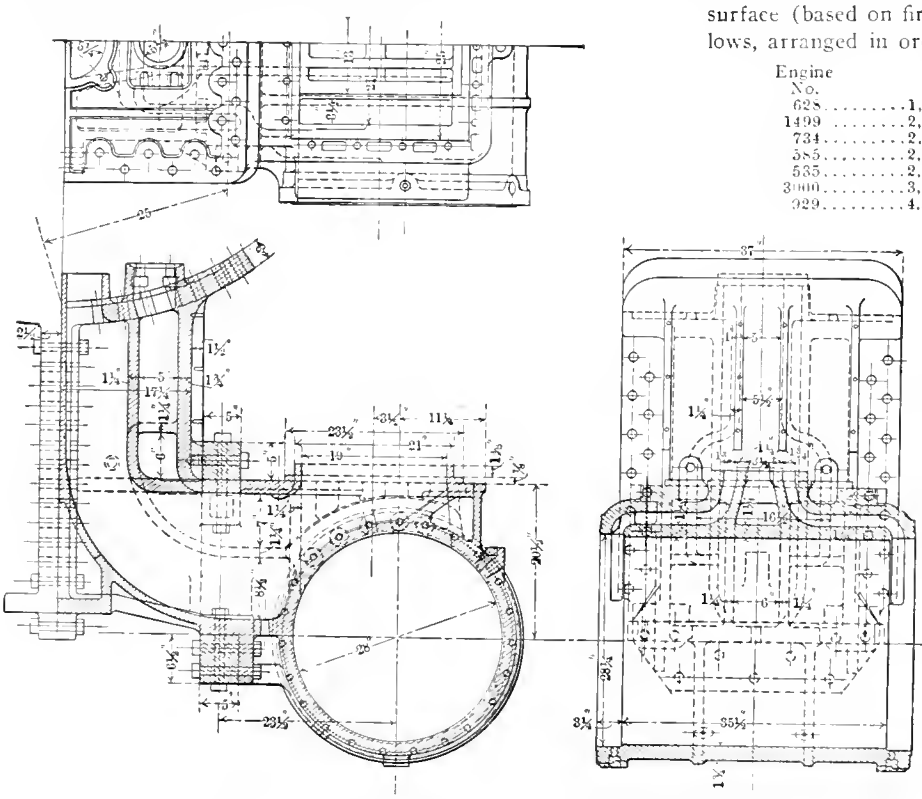
The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	54,100 lbs.
Weight in working order	260,100 lbs.
Weight on drivers	232,700 lbs.
Weight on leading truck	27,400 lbs.
Weight of engine and tender in working order	422,000 lbs.
Wheel base, driving	17′
Wheel base, total	26′ 6″
Wheel base, engine and tender	60′ 10″

RATIOS.

Weight on drivers ÷ tractive effort	4.3
Total weight ÷ tractive effort	4.8
Tractive effort × diam. drivers ÷ heating surface	825.0
Total heating surface ÷ grate area	68.5
Firebox heating surface ÷ total heating surface, per cent	4.8



CYLINDERS—BALDWIN CONSOLIDATION LOCOMOTIVE WITH SUPERHEATER.

Weight on drivers ÷ total heating surface	56.0
Total weight ÷ total heating surface	63.0
Total heating surface ÷ superheating heating surface	4.95
Volume both cylinders, cu. ft	22.7
Total heating surface ÷ vol. cylinders	181.0
Superheating heating surface ÷ vol. cylinders	36.8
Grate area ÷ vol. cylinders	2.66

CYLINDERS.

Kind	Simple
Diameter and stroke	28″ × 32″
Kind of valves	Bal. Slide
Type of valve gear	Walschaert

WHEELS.

Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	11 × 12 in.
Driving journals, others, diameter and length	10 × 12 in.
Engine truck wheels, diameter	36 in.
Engine truck, journals	6 × 12 in.

BOILER.

Style	Straight
Working pressure	160 lbs.
Outside diameter of first ring	84 in.
Firebox, length and width	120 × 72¼ in.
Firebox plates, thickness	⅜ and ⅝ in.
Firebox, water space	6 in.
Tubes, number and outside diameter	472—2 in.
Tubes, length	16 ft.
Heating surface, tubes	3,931 sq. ft.
Heating surface, firebox	198 sq. ft.
Heating surface, total	4,129 sq. ft.
Superheating heating surface	834 sq. ft.
Grate area	60.2 sq. ft.

TENDER.

Wheels, diameter	33½ in.
Journals, diameter and length	5½ × 10 in.
Water capacity	9,000 gals.
Coal capacity	15 tons

SOME NOTES ON THE TESTS AT THE ST. LOUIS EXPOSITION.*

By H. H. Vaughan.

The tests give a large amount of data as to the efficiency of the evaporating surface, but it does not seem possible to separate this entirely from the efficiency of the furnace. By this I mean that, knowing the composition of the flue gases, their firebox and smokebox temperatures, it should be possible to calculate the exact amount of heat transmitted to the flues, but although I have spent a large amount of time on this subject the results were of practically no value. Probably a thorough study would afford some results, but the work is very tedious and the results were not sufficiently encouraging to induce me to devote the time required. Taking the results of boiler and furnace together there are, however, some interesting results, justifying as a whole the use of a large boiler. Neglecting 2512, which was fitted with Serve tubes, the total heating surface (based on fire side of tubes), and grate area was as follows, arranged in order of heating surface:

Engine No.	Heating Surface.	Grate Area.
628	1,753 square feet	29.1 square feet
1499	2,482 square feet	49.2 square feet
734	2,541 square feet	33.8 square feet
585	2,812 square feet	49.4 square feet
535	2,902 square feet	48.4 square feet
3000	3,000 square feet	49.9 square feet
929	4,306 square feet	58.4 square feet

Excepting, therefore, 628 and 929, there was not a great deal of difference in the amount of heating surface in the engines tested, but 1499 and 734, with about 2,500, should show differences as compared to 535 and 3000, with about 2,950, or say an increase of 20 per cent. in the heating surfaces.

The relative value of heating surface should be demonstrated in one of two ways. If heating surface is of the same value, however disposed and of whatever extent, then the evaporation per pound of coal should be the same when equal amounts of coal are burnt per square foot of heating surface per hour. As a test of this I have prepared Fig. 1, showing the equivalent evaporation per pound of dry coal plotted with reference to the dry coal fired per square foot of heating surface per hour. This diagram differs only from that shown in the P. R. R. report by showing the individual values for each test in place of curves dawn through those values. The heavy dotted line is the curve

$$E\left(1 + \frac{R}{2}\right) = 14,$$

where E is the equivalent evaporation per pound of dry coal, and R the pounds of dry coal burnt per square foot heating surface per hour, and it will be seen to be an excellent average of the various results. From this diagram it would appear that the heating surface question was settled, and it would naturally follow that for any given amount of coal burnt a boiler having large heating surface should evaporate considerable more water than one with less. To exhibit this I have plotted Fig. 2, which shows the total evaporation per hour plotted with reference to the pounds of dry coal burnt per hour, from which it will be seen that the results are almost contradictory, as the 50 per cent. increased heating surface of 929 shows no greater evaporation than 585, 535, or 3000.

An inspection of Fig. 1 will show the reason of this apparent discrepancy; for instance, a curve drawn through 929 would intersect the 10.5 lb. evaporation line at about 0.45, while that for 3000 is about 0.67, and for 585 about 0.75. In other

* From a paper presented before the Canadian Railway Club, April, 1907.

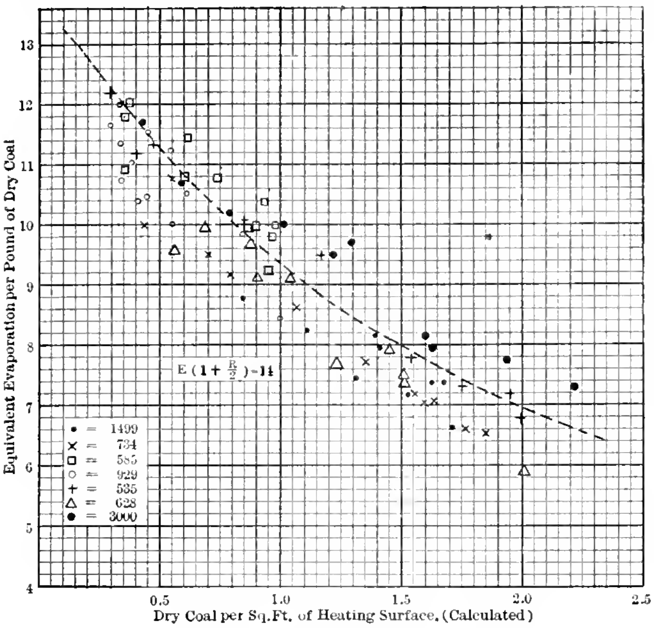


FIG. 1.

words, while the various results are at first sight well grouped, there is sufficient variation between them to entirely correspond with Fig. 2. The question then arises whether Fig. 1 is to be trusted, and the writer believes that further investigation shows that it is, and that factors other than heating surface are responsible for is peculiarities, for the following reasons: The points for 3000, which had the largest heating surface of any engine but 929, mostly lie well above the curve, while those for 535 are almost exactly on it—those for 1499 and 734 generally below it, although several of the former agree almost exactly with it—those for 628 are in general below it—and 585 are above it. These facts show that, with the exception of 929, the engines with the largest heating surface show at least the same and generally greater efficiency than those with the smaller, and if this be so the diagram is justified. The variations must in all probability be looked for in the firebox, and this, I think, explains the specially good results obtained from 3000 at high rates. The firing, while uniformly excellent, was undoubtedly governed somewhat by the demands on it. When the boiler was not so much pressed, the thickness of the fire was not always the best, leading to excess of air or the opposite fault, formation of CO, and this in turn exercised an influence on the results that is almost impossible to accurately measure. The low results of 734 can, of course, be explained by its being a narrow firebox engine, and as for 929 it must be remembered that this engine was never worked to anything like the capacity of its boiler, and it showed a very high percentage of CO, considering the coal burnt per square foot of grate. It does not seem justifiable from the results obtained from this engine to

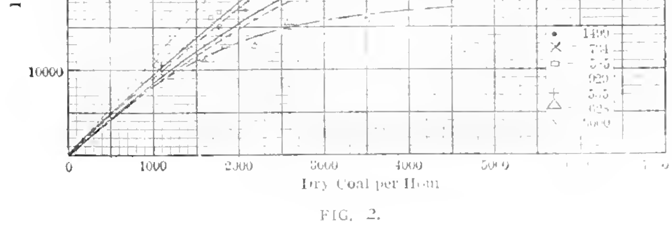


FIG. 2.

dispute the general agreement of the other tests, and it therefore appears safe to consider that the curve drawn represents very closely the evaporation results that will be obtained from a boiler with first-class firing and average conditions otherwise.

It will, perhaps, be as well to take this opportunity to refer to a paper which I read some three years ago on the question of heating surface, and in which I now believe I drew some entirely erroneous conclusions. The value of heating surface was shown to be proportional to the square root of the length of the tubes, in place of their length. In one sense this is true. For instance, if with 1,000 feet of heating surface coal was burnt at the rate of 2,000 lbs. per hour the evaporation would, by Fig. 1, be 7 lbs. If the heating surface were doubled the evaporation would be 9.3 lbs., or 1.33 times as great. Now, as the square roots of 1000 and 2000 are in the proportion of 1.41 to 1.00, there was sufficient truth in this to lead to an attractive fallacy, and, in fact, this was really shown in the discussion. Where the mistake was made was in trying to extend this idea to cover the form of the heating surface, whether in a number of short tubes or a lesser number of long ones, and trying to show that the latter were less efficient. This, I am now convinced, was wrong, as the fact was overlooked that if the number of tubes is decreased the amount of gas and, consequently, of heat through each tube is correspondingly increased. On the assumption that the heat transferred per square foot is proportional to the difference in temperature between the flue gases and the water, this may be shortly demonstrated as follows:

Take two boilers, one with n flues a feet long, the other with m flues b feet long, and let na = mb or the heating surfaces be equal.

Let C = circumference of tube in feet = heating surface per foot of length.

Let T = initial temperature of gases, and t, temperature at

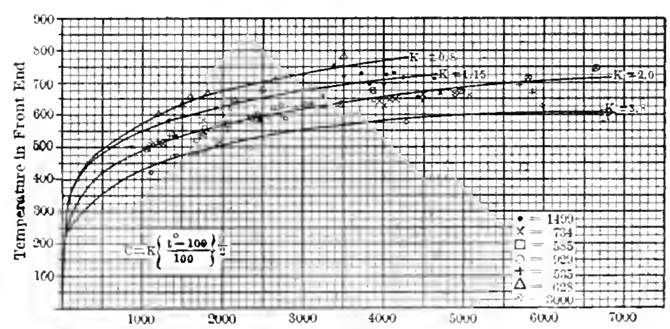


FIG. 3.

any point l feet from the end, above the temperature of the water.

Then in general $\frac{dt}{dl} = -$ Knct or log t $= -$ Kncl + C.

When l = o, t = T, and C = log T.

Then log $\frac{T}{t} = -$ Kncl, and when l = a and t = final temperature

$$\log \frac{T}{t} = -\text{Knca, and if na} = \text{mb} = \log \frac{T}{t} = -\text{Kmbc.}$$

Therefore, for equal areas, t is equal.

The results from 929, which had the longest flues tested, might be taken as an indication that long tubes are less efficient than short ones, but this is an isolated case, and the results from the other engines do not support it in the least. Arranging the engines in the order of the length of the tubes, they are 929, 535, 3000, 585, 734, 628, 1499, and an inspection of Fig. 1 shows that there is not the least evidence for supposing that the length has anything whatever to do with it. This is confirmed by plotting the smokebox temperatures with reference to the coal burnt per hour, which is shown in Fig. 3. In place of drawing straight lines through the points, curves are shown of the form

$$C = K\left(\frac{t^\circ - 100}{100}\right)^{9/2}$$

which fits the case almost exactly and passes through zero coal at 100° Fahr. From these curves it will be seen that the temperature of the gases passing into the front-end of 929 at 4,500 lbs. per hour was less than for the other engines at 3,000 lbs. per hour, so that it is evident that the heating surface did its part, and that the cause for the discrepancy must be looked for elsewhere. The conclusion would, therefore, be that the curve shown on Fig. 1 represents with reasonable accuracy the average result to be obtained under good conditions.

There are a number of other interesting facts to be learned from these tests, but they require, as a rule, considerable study to extract them, and in many cases they are extremely difficult to trace out. As an example, why should the boiler of 585, which shows the lowest firebox temperatures, form usually no CO and be so efficient? And in the one case when its efficiency drops off the firebox temperature is higher, but the draft is for some reason lower than usual in proportion to the steam used. Such an occurrence might be accidental, or it might be due to some cause that a careful examination would detect. Broader questions are open for study, the frictional loss, the effect of counterbalancing, the value of Serve tubes, the reason for the decreased economy of the two-cylinder compound at high speed as compared with the four-cylinder, the effect of excess of air in the firebox, and numerous others that will suggest themselves to you, but these I am not in a position to discuss, and probably would not be even did time permit. One thing more that I wish to say, and that is that we should all realize the debt we owe the Pennsylvania Railroad for its broad-mindedness and generosity in carrying out such a series of tests, and the light they have thrown on that most complicated and contradictory of man's inventions, the steam locomotive.

Timber Supply of the United States.—A recent circular of the U. S. Forestry Service, which deals with the timber supply of the United States contains some remarkable statements. As an instance, it states that every person in the United States is using over six times as much wood as he would use if he were in Europe. The country as a whole consumes every year between three and four times more wood than all the forests of the United States grow in the meantime. The average acre of forest lays up a store of only 10 cubic feet annually, whereas it ought to be laying up at least 30 cubic feet in order to furnish the products taken out of it. Since 1880 more than 700,000,000,000 feet of timber have been cut for lumber alone. It is pointed out in the circular that the increase in population since 1880 is barely more than half the increase in lumber cut in the same period. Two areas supplying timber have already reached and passed their maximum production—the Northeastern States in 1870 and the Lake States in 1890. To-day the Southern States, which cut yellow pine amounting to one-third the total annual lumber cut of the country, are undoubtedly near the maximum. The Pacific States will soon take the ascendency. At present but one-fifth of the total forest area of the United States is embraced in National Forests. The remaining four-fifths have already passed or are most likely to pass into private hands.

The Chicago Tunnel System for handling freight, mails, etc., will probably soon be doing a large freight business, as it is reported that contracts have been made with 26 railways for the handling of their freight between the business district and the several freight stations. There are now about 30 miles of tunnel with narrow gauge tracks, operated by electric motors, and mails are now carried in this way between the railway stations and the post-office. Large establishments have spur tracks built into or beneath their basements, and six stations for the use of small shippers are being established in the business district. These are served by elevators.

VALVE ELLIPSE INDICATOR.

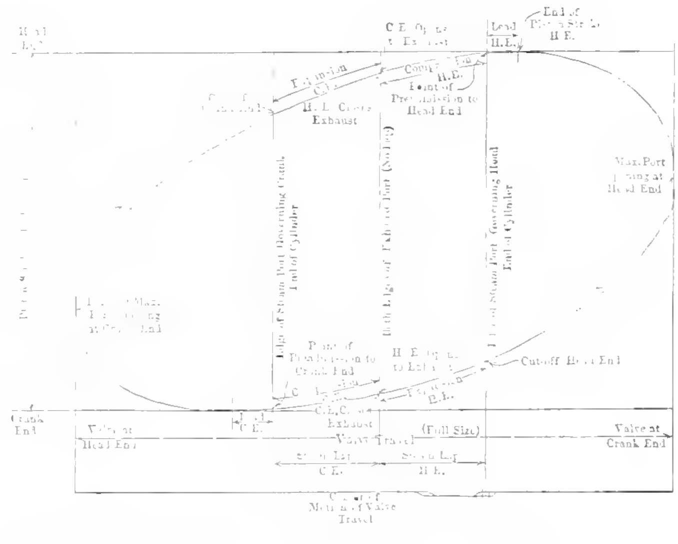
A valve ellipse is a diagram showing the position of the valve on its seat and the location of the piston in the cylinder at all times during the double stroke of a locomotive or stationary steam engine. Such diagrams are often constructed on drawing boards preliminary to erection or valve setting of an engine and are of much value in studying the proper adjustment of the valves, etc.

There have also been instruments made with which the ellipses are drawn by pencils attached to the piston and valve of the engine itself after the valves were set. The instrument of this kind shown in the illustrations is one designed by the Baldwin Locomotive Works and used by them to study valve setting on locomotives. The general ideas incorporated in this instrument were first used by Prof. Lanza of the Massachusetts Institute of Technology.

The paper on which the diagram is drawn is placed on the large drum in the same way as on a steam engine indicator and the drum is rotated by the movement of the valve. This is accomplished by attaching the chord from the drum to a standard firmly clamped to the valve stem. A pencil carried in a guide parallel to the axis of the drum is attached to a reducing motion from the crosshead so that it can be given a movement of about 3 in. from any length of stroke of the engine. A second pencil attached to this guide is given a very small movement parallel to the axis of the drum by an electric magnet in which the circuit is completed when the valve just closes one of the steam ports. The guide carrying the two pencils is movable parallel to itself, towards and away from the drum, so that the pencils do not mark on the paper until it is so desired.

The instrument is made to be self-contained in order that it may be quickly applied to a locomotive.

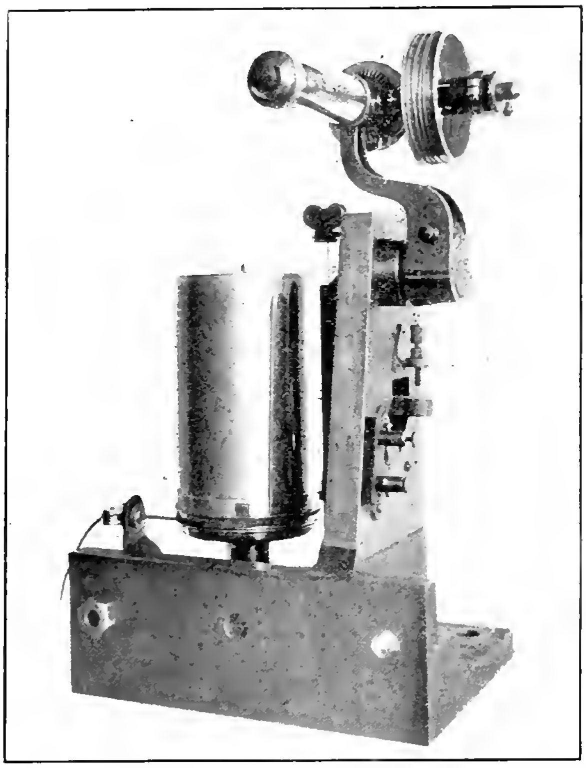
The usual procedure is to build a small wooden platform over the steam chest, either longitudinal or inclined. The valve ellipse indicator is then bolted to this platform in such a position that the string from the reducing wheel can be led to the crosshead with the use of the fewest possible pulleys. Also it must be possible to run the string from the drum directly to a standard clamped to the valve stem without the use of any pulleys.

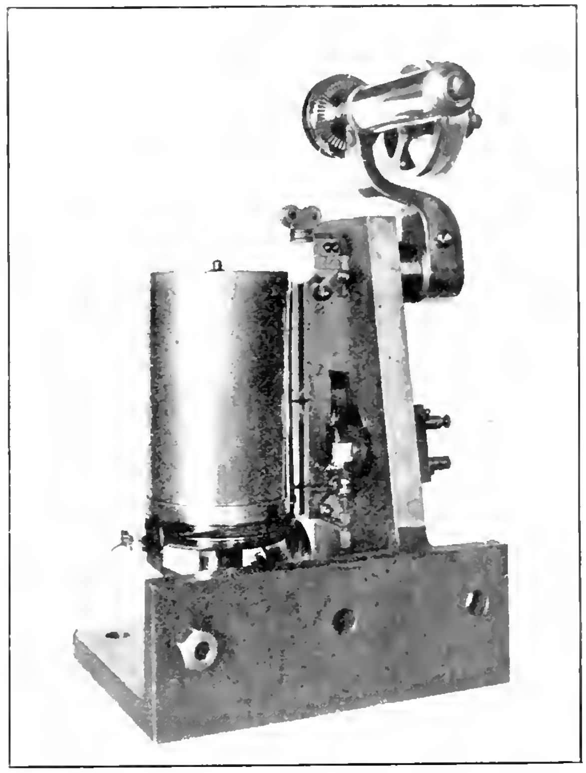


	On Diagram		Per Cent. Stroke	
	Head	Crank	Head	Crank
Lead	.28"	.39"	......	.....
Pre-admission	[illegible]	.025"	[illegible]	.045
Cutoff	[illegible]	2.77"	85.4	82.57
Release	[illegible]	3.17"	[illegible]	94.49
Compression	1·5"	155"	5.5	4.62
Maximum port opening	1.74"	1.845"	.....	.....

Valve travel = 5.5-5".
Stroke = 3.355" on diagram.

SAMPLE DIAGRAM FROM VALVE ELLIPSE INDICATOR—WALSCHAERT VALVE GEAR.



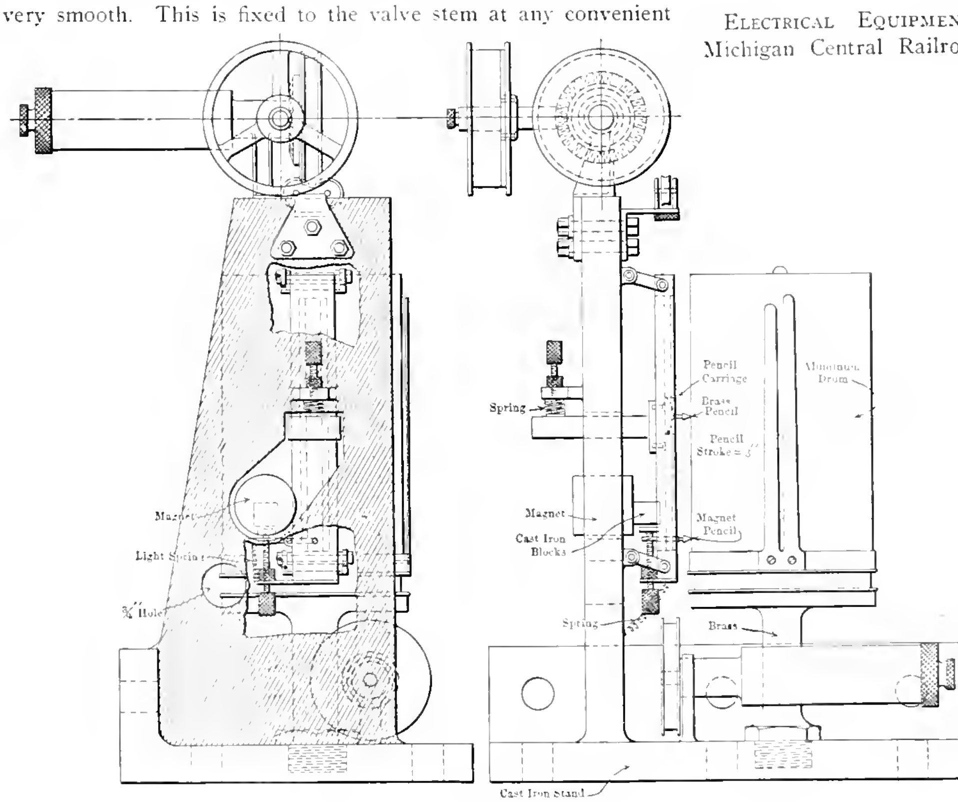


TWO VIEWS OF THE BALDWIN VALVE ELLIPSE INDICATOR.

It is allowable to have the reducing motion actuated by the cross-head run all the time the engine runs, but provision must be made to disconnect the drum from the valve stem so that new paper may be applied.

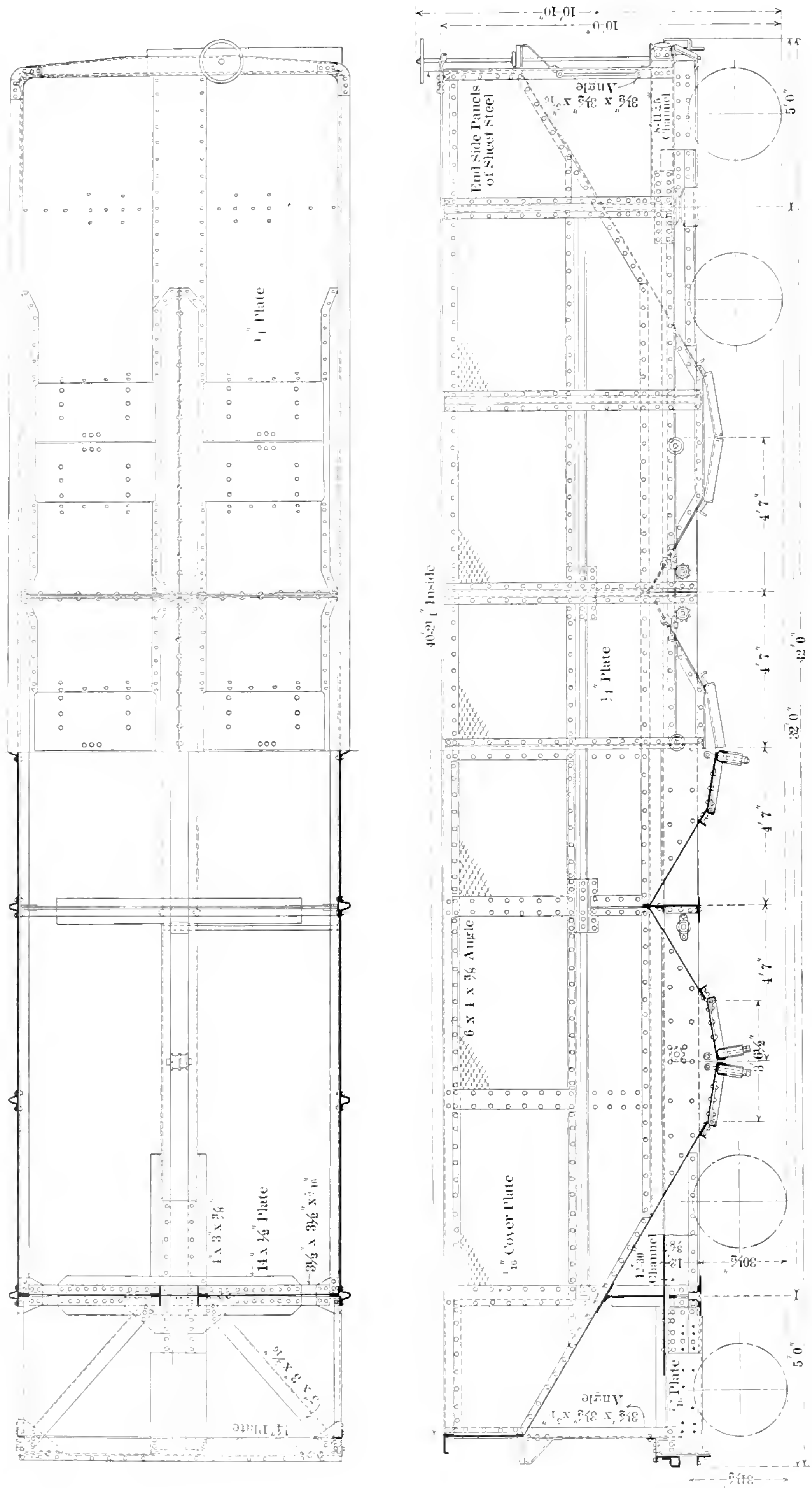
The electrical connections for moving the lower pencil which locates the port lines on the diagram, are made in such a way that in one circuit are contained, 1st, the two terminals on the valve ellipse indicator; 2nd, a primary battery of about 7 volts; 3rd, the contact points, one of which is fixed while the other moves with the valve stem. The contact attached to the valve stem is made in the form of a quadrant half of steel and half of non-conducting fibre set together so that the curved surface is very smooth. This is fixed to the valve stem at any convenient point and then insulated from it, the chord of the arc being parallel to the axis of the valve stem.

The contact point which is fixed to the steam chest or guides is a steel point which is set to rub over the quadrant on the valve stem. It has a spring above it to insure plenty of lift over the arc and is set in a cross-head with adjusting screws so that it may be located directly on the line between the steel and non-conducting parts of the quadrant when the valve is just closing one of the steam ports. The valve can be set in the proper position with a regular valve tram by the port marks on the valve stem.

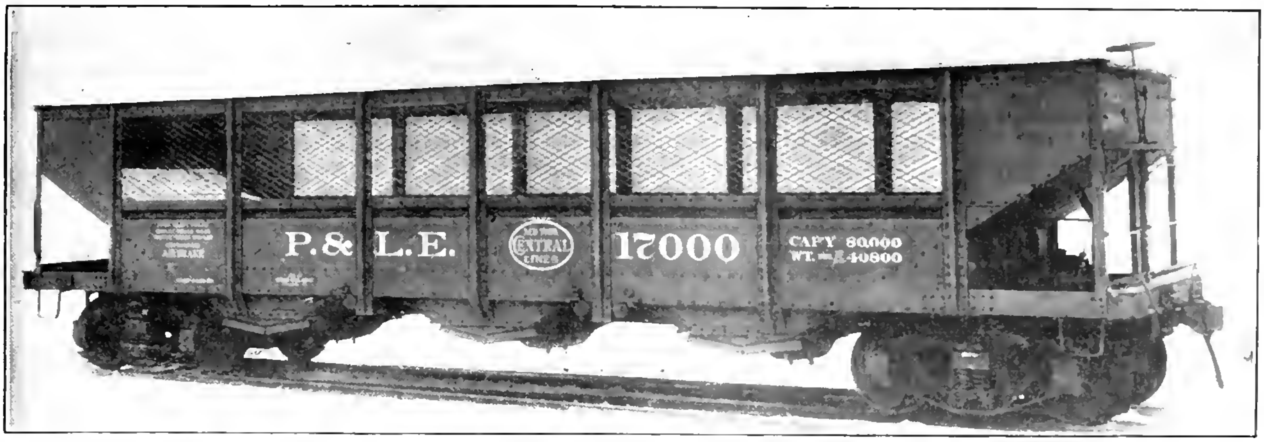


DETAILS OF VALVE ELLIPSE INDICATOR.

Electrical Equipment in Detroit River Tunnel.—The Michigan Central Railroad is constructing a tunnel under the Detroit River between Detroit and Windsor, Can., through which all passenger and freight trains will pass. The trains will be operated through this tunnel by electric locomotives, the electrified zone being 4.6 miles in length. Six 100-ton direct-current locomotives of the swivel truck type, with geared motors, will comprise the initial equipment, each locomotive being capable of handling a 900-ton train up a 2 per cent. grade at a speed of 10 miles per hour. Four 280 horse-power motors will be mounted on each locomotive, and the Sprague-General Electric multiple unit control system will be employed for operating the locomotives together if desired. Current will be taken from the third rail, the power being purchased from the Detroit Edison Company, a pressure of 650 volts being used. A very complete electric lighting and pumping equipment will form part of the project. The electric equipment throughout is being furnished by the General Electric Company.



PLAN, ELEVATION AND SECTIONS OF TRIPLE HOPPER STEEL COKE CAR—PITTSBURG AND LAKE ERIE RAILROAD.



TRIPLE HOPPER STEEL COKE CAR—PITTSBURG AND LAKE ERIE RAILROAD.

STEEL, TRIPLE HOPPER BOTTOM, SELF-CLEARING COKE CAR.

PITTSBURGH AND LAKE ERIE RAILROAD.

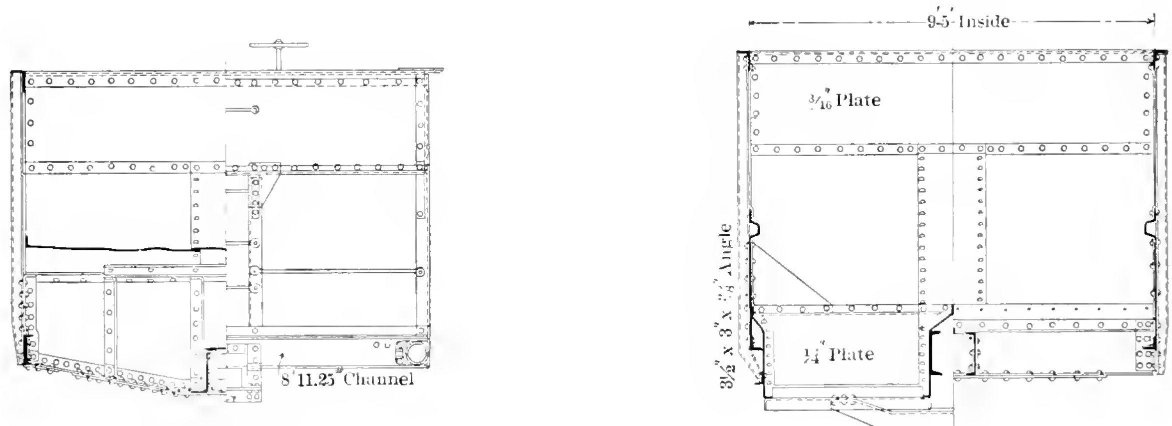
The Pittsburgh & Lake Erie Railroad has recently received, from the Standard Steel Car Company, 1,000 all-steel, 80,000-lb capacity, coke cars, which are the first 40-ft. coke cars to be built that are entirely self-clearing and are also the first steel cars with triple hoppers, if we except the "three-pot" hoppers with iron bodies and wooden underframes, which were used extensively on the Baltimore & Ohio Railroad for several years, as noted on page 160 of our May issue. The general design of these cars was worked up by Mr. L. H. Turner, superintendent of motive power, and Mr. W. P. Richardson, mechanical engineer, under the direction of Col. J. M. Schoonmaker, vice-president and general manager of the road. The Standard Steel Car Company adapted their detail designs to this general design. One thousand more of these cars have been ordered with the sides 6 in. higher.

The cars have a capacity of 2,406 cu. ft., level full, or 2,580 cu. ft. with a heap one foot high at the center. They are designed to carry a maximum lading of 88,000 lbs., which may be loaded directly over the hoppers, thus adapting them for carrying such material as ore, billets, etc., on the return trips. The general dimensions of these cars are as follows:

Length over striking plates	42′ 0″
Length inside	40′ 2¼″
Width over side stakes	10′ 0″
Width inside	9′ 5″
Height from top of rail to top of side	10′ 0″
Height from top of rail to top of brake mast	10′ 10″
Height from top of rail to top of center channels at bolster	3′ 6½″
Height from top of rail to bottom of center channels at bolster	2′ 6½″
Height from top of rail to center of drawbar	2′ 10½″
Length of door openings	3′ 5½″
Width of door openings	3′ 6½″
Distance from center to center of trucks	32′ 0″
Truck, wheel base	5′ 6″
Truck, journals	5″ × 9″
Weight	40,800 lbs.

The center sills are 12-in., 30-lb., channels. They are placed with their flanges facing inward and extend through and beyond the body bolster about 20 in. Draft sills of 7/16-in. steel, pressed in a Z-shape form, 12¾ in. deep, are spliced to them, as shown. Each center sill is reinforced by a 4 x 3 x ⅜-in. angle, riveted at the bottom on the outside and extending from near the hopper sheet, through the bolster, to the end of the center sill channel. The center sills are also reinforced at the body bolster by a ⅜-in. top cover plate.

The lower half of each side of the car between the bolsters consists of a ¼-in. plate with the upper edge pressed to the shape shown on the drawing, to add to its stiffness, and with a 3½ x 3 x ⅜-in. angle riveted at the lower edge. This side girder is tied to the center sills between the bolsters by the hopper construction and also by the cross ties between the hoppers. These latter consist of a pressed steel diaphragm between the two center sills and a vertical plate flanged at the lower edge, which extends between the center sills and the side girders. The upper part of this plate extends the full width of the car and is reinforced by a light angle which is riveted to it, and by the upper edges of the hopper sheets. A bottom cover plate, forming part of the cross-tie, extends the greater part of the width of the car. An 8-in., 11¼-lb., channel extends from the body bolster to the end sill, forming a side sill extension.



CROSS SECTIONS OF TRIPLE HOPPER COKE CAR—PITTSBURG AND LAKE ERIE RAILROAD.

The body bolster is a ¾-in. vertical plate cut out at the center to fit over the center sills. This plate is flanged at its upper edge to conform to the slope of the hopper sheet and is riveted to this sheet, which is reinforced by a ¼-in. plate, as shown. The bolster plate is reinforced by 3½ x 3½ x 5/16-in. pressed angles placed vertically, and also by similar angles riveted on each side along the lower edge. Two pressed steel diaphragms, placed back to back, are placed between the center sills and riveted to them. A bolster tie plate, ½ in. thick and 14 in. wide,

extends across the bottom of the bolster for nearly the width of the car.

The end sill is an 8-in., 11¼-lb., channel, reinforced at its upper edge by a plate which is flanged at its rear edge and riveted to the uprights, or posts, at the end of the car. The end sill is reinforced at the center by a cast steel coupler striking plate. The coupler carry iron is a 5 x 3½ x ⅜-in. angle iron. Piper friction draft gear is used with a 5 x 1-in. draw bar yoke.

The side and hopper sheets are ¼ in. thick. The vertical sheet at the end of the car is 3/16 in. thick and is reinforced at its upper edge by a ½-in. plate pressed as shown. The top of the side of the car is a 6 x 4 x ⅜-in. angle. The end side panels of the car are of sheet steel. The other panels between the side sheet and the top angle are of expanded metal, No. 6 gauge, 3-in. mesh.

There are two sets of drop doors over each hopper, which are operated in unison by the simple type of drop door mechanism shown on the drawing. The doors for the different hoppers are operated independently. The cars are equipped with Hartman ball bearing center plates and side bearings, the center plates being of drop forged steel and the side bearings of malleable iron.

The trucks have the Andrews cast steel side frames and are equipped with Simplex bolsters.

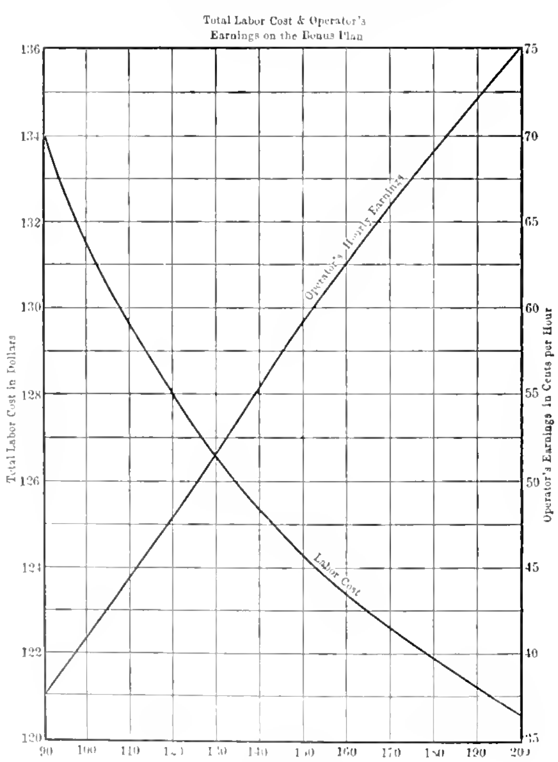
H. J. DOE'S WAGES

To the Editor:

I do not wish to clog the columns of your paper with an unprofitable discussion, but "Individual Effort" (page 287, July issue) did not make clear the point that I tried to bring out in "What's the Use?"

I saw the bonus of $46.34, also the amount of wages $79.22, and inasmuch as Doe's creditors would hardly place a premium on a bonus dollar, I added the amounts together, supposing that total earnings was the real key to the situation.

The accompanying curve shows the relation existing between per cent. efficiency and total earnings, total earnings being based



on 322.6 standard hours at a rate of $3.40, other data for the calculations being taken from page 223, June number.

Suppose we consider that H. J. Doe has a task assigned to him, that, by the company's estimate, is worth 322.6 standard hours; suppose that he performs the task with an efficiency of 90 per cent., which will hold the job for 358.5 hours, and will cost the company $133.97. Then suppose that he works with an efficiency of 200 per cent., he will hold the job out only 161.3 hours, it will cost the company only $120.65, a saving to the company of 197.2 hours, and a further saving, due to reduced wages paid to Doe, of $13.32. As the average month has 260 working hours, Doe could, of course, work the remaining 98.7 hours with a probable efficiency of 200 per cent., thereby raising his wages to a very high figure, but why should he be fined $13.32 for raising his efficiency from 90 per cent. to 200 per cent. on a given amount of work? Marvin Ellis.

Youngstown, Ohio.

To the Editor:

Referring to the above communication from Marvin Ellis, I judge from it that:

(1) Marvin Ellis does not like the contract.

(2) He does not consider it equitable.

This divides the question into two parts, which we will consider separately. The first is a case of individual taste and not of individual effort, and as far as tastes are concerned everybody has a right to his own.

The contract Mr. Ellis does not like is:

(1) The operator is guaranteed day pay even if he is not occupied and turns out no work.

(2) Assuming his monthly wages to be $100 for the time he worked on standard jobs, he is given for making or passing 100 per cent. efficiency a bonus of $20.

(3) If he passes 100 per cent. efficiency he is paid in addition at his hourly rate for all the time he saves. If his hourly rate is $0.40, standard time 20 hours, and the work is done in 10 hours, which is an efficiency of 200 per cent., he receives:

(a)	$0.40 an hour for 10 hours..............	$4.00
(b)	20% as a bonus on above amount......	.80
(c)	$0.40 an hour for the 10 hrs. saved.....	4.00
	Total earnings for day of 10 hrs........	$8.80

It is Mr. Ellis's privilege not to like this contract. I also have dislikes. I dislike to see an ambitious, willing, skilful man urged by a driving foreman to 200 per cent. efficiency and then get nothing but day rate for his reward.

I dislike to see a man on piece rate make tremendous effort and lose out because his machine is out of shape, his belts poor, his tools inferior. I dislike the Halsey plan which sets a standard and then gives the unusually efficient worker from one-third to one-half of the saving in his own time.

Compared to these methods the Individual Effort Contract stands out as altruistic and philanthropic.

Mr. Ellis claims that the contract is inequitable. He bases his claim on the fact that if a man works at 200 per cent. efficiency his earnings are not twice what they are at 100 per cent. efficiency.

Ought they to be? Mr. Ellis says yes. I say no.

Twin brothers are working equally at 100 per cent. efficiency on the same machine, one 10 hours on the day shift, the other 10 hours on the night shift. The day man comes to the boss and says: "My brother wants to lay off. I will double my efficiency to 200 per cent. and do all his work in addition to my own in 10 hours. Give me his wages in addition to my own." The boss replies: "Not if I know it. I have now two good reliable men of 100 efficiency who can work year in and year out at this rate without damage to self or to the equipment. If one is absent the other can temporarily take an overload of 50 per cent. for a day, even of 20 per cent for a week, so that I am only partly and temporarily incapacitated by the absence of the other. You propose permanently to overload 100 per cent., to break yourself down, nervously and physically, to leave me without anyone when you collapse. You propose to rack the machine to pieces and wear out the tools, you propose in part to disorganize the shop by your unreasonable pace, just as a man attempting to run in a crowded street where everybody else is walking, jostles all and causes in the aggregate more delay than he saves on himself. We do not wish to check reasonable ardor, but we shall charge a little

something for the damage and extra cost you are putting us to. You know perfectly well that a boat requires eight times as much power to go twice as fast, and our aim is not to have some men going twice as fast but to bring up all the shop to high efficiency. We tolerate 60 per cent. men and we tolerate 200 per cent. men, but we disapprove of both."

INDIVIDUAL EFFORT.

To the Editor:

Marvin Ellis and "Individual Effort" in your July issue are mighty worried over the theory of my pay check, and the former gentleman's article at first caused me to worry a good deal. It certainly did seem from his figures as if my wife and children were out $1.09 worth of theatre and silk dresses every time I humped myself over 129 per cent. efficiency. Now it took us two months and lots of suspicious questions to get next to the Individual Effort pamphlet foisted upon us, but we finally did think we knew it all, and were satisfied until Mr. Ellis apparently discovered how the company is doing us after all, in spite of the $132.41 extra earnings I made in four months.

My wife hasn't been to high school for nothing, however, and she also strongly disapproved of my going back to straight day work, on account of that one hundred and thirty dollars. So we went all over it again, and we now look at it this way:

A farmer, in figuring his gain at the end of the year, deducts his keep; I guess the president of this road doesn't reckon his salary as part of the company's profits either. Now we claim, in the same way, that the money that really appeals to us is the money we don't have to give away.

When I worked by the day, I used to average $80 a month, but $75 of that amount was gone after twenty-four hours in paying our bills, including $5 we put in the bank. It was the extra five-dollar bill that would cheer us up, and that we'd blow in.

COMPARATIVE EARNINGS FOR TWO MONTHS.
Total Standard Time for all Bonused Jobs being 322.6 hours, and Standard Rate $3.40.

Efficiency.	Time Work'g on Bonus.	Wages while on Bonus.	Bonus per cent.	Bonus Am'nt.	Total Earnings.	Same, less Living Expns.	Comparative Perc'nt'g's.
65%	470.0	$159 80	....	....	$159.80	$9.80	100.0%
80%	403.2	137.09	3.27%	$4.48	164.28	14.28	145.7%
90%	358.4	121.86	9.91%	12.08	171.88	21.88	221.6%
100%	322.6	109.69	20.00%	21.94	181.74	31.74	323.9%
110%	293.3	99.72	30.00%	29.92	189.72	39.72	405.3%
120%	268.8	91.39	40.00%	36.56	196.36	46.36	473.1%
150%	215.1	73.13	70.00%	51.19	210.99	60.99	622.3%
200%	161.3	54.84	120.00%	65.51	215.61	75.61	771 5%

In the above table, based on figures on page 223 of your June issue, my wife shows (and I hope she's right) how much money we have *left over* at the end of every two months, for a certain number of efficiency figures on my part.

With the schedules as now given out to the shop, any man should get up to 90 per cent efficiency and have time to spare. Supposing he does, for every dollar he could get enjoyment out of when he worked by the day, he now has $2.22.

If he cuts out his waste time, and gets down to business, I know he can reach 110 per cent. efficiency, month in and month out, without hurting himself; and he then has over four times as much money to spend on luxuries as he had before.

My wife figures that I have $66.20 every two months, or $33.10 every month to buy her new hats with, while I used to have barely $5 left over.

I cannot deny Mr. Ellis's figures. But, were he in my shoes, I think that after wasting two or three hours in covering several sheets with figures, he'd look at his bank account increasing at an unusual rate, and say: "What's the use?"

Topeka, Kansas H. J. Doe.

FOUR CYLINDER SIMPLE LOCOMOTIVE.

To the Editor:

The very fine four-cylinder, balanced, non-compound, Atlantic type express locomotive of the Great Western Railway (England), which was illustrated and described in the American Engineer and Railroad Journal for February last, pages 56-59, has been run upon the testing plant at the Swindon Works of the company, and *The Engineer* (London), in its impression of July 5, contains the following interesting remarks relative to the performance of this engine: "The highest speed attainable was 67½ miles an hour. Beyond this the air-compressing brake *could not absorb the power.* The steady running of this type of engine, as compared with the ordinary two-cylinder engine, is quite remarkable. At 60 miles an hour, the hand placed on the front buffer beam *felt little more than a tremor.* With two cylinders, at that speed, the lateral oscillation on the bogie is quite violent." The italics are mine.

Edward L. Coster,
Assoc. Am. Soc. M. E.

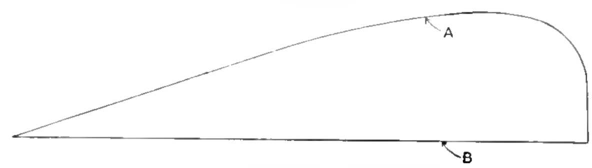
25 Broad Street, New York.

LENGTH OF A CURVED LINE.

To the Editor:

Did you ever try to get the length of a line bounding an irregular figure with the planimeter where more accurate results were desired than by spacing off with dividers?

It is accomplished thus: Take the reading of the instrument in square feet or inches, as the case may be, and extract the square root, which will give the length of one side of a square of equal area and this multiplied by 4, the number of sides, will give the length of the surrounding line.



Take a figure as shown above. The length of "a" can be obtained by subtracting the length of "b" from the result as obtained above. W. O. Moody.

Mech. Eng. I. C. R. R., Chicago.

First American Turbine Steamship.—It has been erroneously stated by a number of the railroad papers that the "Creole," which is now being operated in the New York, New Orleans service of the Southern Pacific Company, was the first large turbine steamship of American manufacture to be commissioned. As a matter of fact the "Governor Cob" of the Eastern Steamship Company of Boston, which was launched on April 21, 1906, and went into commission in October of the same year, was the first large ship of this type to be built in America. This ship has a length of 290 ft. on the water line, a width of 51 ft., a draft of 14 ft. and a tonnage of 2,184. It is equipped with Parsons turbines of 5,000 h.p. and is driven through three shafts. The next large ship of this type to be commissioned was the "Yale" of the Metropolitan Steamship Company's fleet, which was launched on December 1, 1906, and placed in commission June 27, 1907. This vessel measures 407 feet over all, has a 63 ft. beam and draws 16 ft. of water. It also has three turbines, giving a total of 10,000 h.p. The turbines in both of these cases being arranged with the high pressure in the center driving one shaft and two low pressure and reversing turbines driving the two other shafts. The "Creole" is thus apparently the third ship of this type instead of the first. It measures 440 ft. over all with a 57 ft. beam and displaces over 10,000 tons. The turbines for the "Governor Cob" and the "Yale," and also for the "Harvard," a sister ship to the "Yale," are of the Parsons type and were built by the W. & A. Fletcher Co. of Hoboken, N. J.

Safe Ferry Service.—It is estimated that during the 40 years of regular ferry service across San Francisco Bay that 300,000,000 passengers have been carried. During this time but three lives have been lost. The monthly average of passengers now being carried is above the 2 million mark.

About 600,000 persons are dependent on the Pennsylvania Railroad lines for a livelihood.

(Established 1832).

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Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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The number of engine failures reported as due to "poor coal" and "boiler foaming" with attendant "leaky boiler" will be found on many roads to be a pretty large percentage of the total number. In many cases the excuse of "poor coal" will come from but one or two crews on a division and the indications are that the real trouble is "poor fireman." Also the boiler foaming explanation will be given where nothing but treated water is being used and the probable trouble is careless handling of injectors and throttle. However, as cases have been known where there was one car of a very poor coal in a large supply of generally excellent fuel and water treating plants have been known to suddenly go wrong for short periods, it would not do to designate the engineman by that short and ugly word without more positive proof.

It is to meet such conditions and put accurate information, on which just action can be taken, in the hands of the divisional superintendents of motive power, that a movement is being started of equipping some of the larger divisional points with what is locally known as a "chemical laboratory." This consists simply of a coal calorimeter and a few simple reagents and equipment for water testing. Orders are issued that all reports of engine failures due to poor coal shall be accompanied by a fair sample of the fuel which can be quickly tested and the proper action immediately taken to correct the trouble, wherever it may be. Samples of the water supply are also obtained from stations out of which foaming boilers are reported. Where water softening plants are in general use a daily sample may be advisable during certain periods of the year when the quality of the raw water may fluctuate widely.

Such an equipment does not require an expert chemist nor the whole time of any employee, and it is easy to see how it could prove to be an excellent investment at points where these troubles were frequent.

Consider for a moment the most successful foreman, official or even president you know. The one whom the men all admire and for whom they gladly work overtime or give up a long planned outing to help out of a tight fix. The one whose men are working for the road and are proud of it. You know such a man; we all do; luckily they are not so very scarce. What kind of a man is he? Does he have a grouch three days a week? Does he overlook the wiper's "good morning"? Does he send out word that he is too busy to see you when you call at headquarters? Are the men afraid to ask him for a small favor? Does he have any difficulty in getting apprentice boys? No? Why not?

Think it over; possibly the secret is not so very deep.

In his paper "Causes of Leaks in Locomotive Boiler Tubes," presented at the last M. M. convention, an abstract of which appears on page 315 of this issue, Mr. M. E. Wells, who has made this subject a special study for a number of years and who is undoubtedly in a position to speak authoritatively upon it, states that the generally accepted idea of cold air entering through the fire-box door being principally responsible for leaky flues is erroneous and that the real source of the trouble is in the ejection of cold water, causing unequal variation of temperature at different times in different parts of the boiler. This, together with the deposits of incrustation, are stated to be the two great causes of all boiler leakage.

The experiments made a number of years ago on the Chicago, Burlington & Quincy Railway and the improvement which has been obtained on that and other roads along lines indicated by the results of those experiments show that Mr. Wells's point is well taken. While, of course, he recognizes the value of the rules governing pumping and of devices for thorough mixing of the entering feed, still these are not the remedies which he suggests. The trouble is in the introduction of comparatively cold water into the boiler and the logical correction of such a difficulty is to heat the water before putting it in, and that is what is recommended in this paper. A feed water heater does not necessarily have to be a complicated device and while it may require the use of pumps in place of an injector it would appear that the very probable results would be well worth the effort.

In tests of any kind the most important feature is accuracy and this has been made the keynote in the design and construction of the dynamometer car, recently completed by the Pennsylvania Railroad, an extended description of which is given on page 293 of this issue. No expense or trouble has been spared in making this car the finest of its kind and delicate refinements of adjustment and construction, which are usually associated only with high class physical and chemical labora-

tories and have heretofore been considered unnecessary for tests of such powerful machines as locomotives, have been introduced in this car.

The possession of this excellent instrument for the testing of locomotives in actual service, taken in connection with the locomotive testing plant for testing under controllable conditions, gives this company a most exceptional equipment, and an opportunity for studying locomotive design such as has never before been available.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The tenth annual meeting of the American Society for Testing Materials was held in Atlantic City, June 20th to 22nd. The attendance was the largest in the history of the society, there being 268 members and guests present. The total membership in the society is now 925 as compared with 835 last year.

The program for the three days' meeting included 61 separate subjects, and two sessions were held each day. Even under these circumstances it was practically impossible to cover the work outlined and it was necessary to read many of the papers by title only and to dispense with discussion. Even when the society is divided into two sections, each holding its sessions at the same time in different meeting rooms, it is easily evident that three days is not sufficient for the work of the association and it is probable that next year four or five days will be allotted.

Probably the most important work accomplished at this meeting was the acceptance of a report of the committee on standard specifications for steel rails and the decision to submit it to letter ballot.

The paper which probably attracted the most attention was one on the subject of "Corrosion of Iron," by Allerton S. Cushman, Assistant Director, Office of Public Roads, Department of Agriculture, Washington, D. C. Detailed experiments of great value, bearing on the theory that rusting is a product of electrolytic action, were reported. This paper was thoroughly illustrated by lantern slides.

Among the many other interesting reports and papers might be mentioned one by Mr. S. S. Voorhees, which gave an account of the practice of the U. S. government in purchasing coal by specifications. These specifications are based on a definite number of British thermal units for one cent and it has been possible to obtain in egg coal 50,000 B. T. U.'s; in furnace coal 53,000 B. T. U.'s, and in pea coal 64,000 B. T. U.'s for one cent. A number of cases were cited where bituminous coal has also been purchased according to similar specifications. The paper by Mr. Robert Job on the "Causes of Failure of Cast Iron in Service" was of much interest and value. It dealt quite largely with the selection of the proper grade of pig iron and the use of ferro-manganese in making locomotive castings.

The address by the president, Dr. C. B. Dudley, upon the subject of "Enforcement of Specifications" was a most valuable and interesting treatment of this difficult subject. He laid special emphasis upon the great importance of the railroads using special care to exclude defective material, especially where it might affect the safety of transportation or the lives of passengers. Dr. Dudley drew special attention to the fact that producers and dealers in railway supplies with practically no exceptions, preferred to do an honest business at a fair price and would always do so if it were not for certain conditions. Among these conditions he mentioned badly worded specifications, whose meaning was not perfectly clear, also unreasonable requirements in specifications. Again the mistakes of subordinates are frequent causes of trouble, an instance mentioned being where five barrels of an inferior grade of oil were included in an order of 50 barrels by a foreman who had only 45 barrels of the proper grade at hand. Some other similar affecting conditions were also mentioned. The whole address is full of good advice on the proper procedure in testing materials and the course to be taken in those found to be defective.

The meeting as a whole was the most successful in the history of the society.

CONVENTION OF THE MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.

The thirty-eighth annual convention of this association will be held in St. Paul, Minn., September 10 to 13. The Hotel Ryan has been selected as headquarters and low rates, which can be obtained by addressing the secretary, have been secured. Since several other organizations are scheduled to meet in St. Paul at this same time it is advisable for all who desire to locate at headquarters to secure their accommodation at the earliest possible date. The subjects to be discussed at the convention are as follows:

The painting of steel passenger equipment. (a) How should the interior be treated? (b) How should the exterior be treated? A composite paper by John D. Wright, H. M. Butts and R. J. Kelly.

Plainness, problems, perplexities and prophecies, pertaining to the present day railway paint shop. Individual paper by Chas. E. Copp.

Disinfecting passenger cars at terminals. What is the most improved method of disinfecting passenger equipment at terminals to comply with state laws? H. E. Smith, R. W. Mahon, and A. J. Bruning.

The cleaning, coloring and lacquering of metal trimmings, lamps, etc., for passenger equipment cars. B. E. Miller, Geo. Warlick and Chas. A. Cook.

Painting locomotives and tenders. (a) What parts should be varnished? (b) What parts can be treated with enamels to advantage? (c) Is it advisable to use asphaltum or oil paints? John H. Kahler, W. A. Buchanan, and Eugene Daly.

To what extent may the various linseed oil substitutes and drying oils be used in the painting of cars and locomotives? W. O. Quest and W. H. Smith.

Queries.—Have you found any material or coating that will resist the action of rust? Discussion to be opened by Chas. E. Becker.

Denatured alcohol. Is it a satisfactory substitute for pure grain alcohol for railroad painters' use? Discussion to be opened by W. J. Orr.

Is it advisable to apply three coats of body color to a car, if two coats will cover? Discussion to be opened by John Gearhart.

Can the lasting qualities of light colored freight car stencil paints be improved? Discussion to be opened by Warner Bailey.

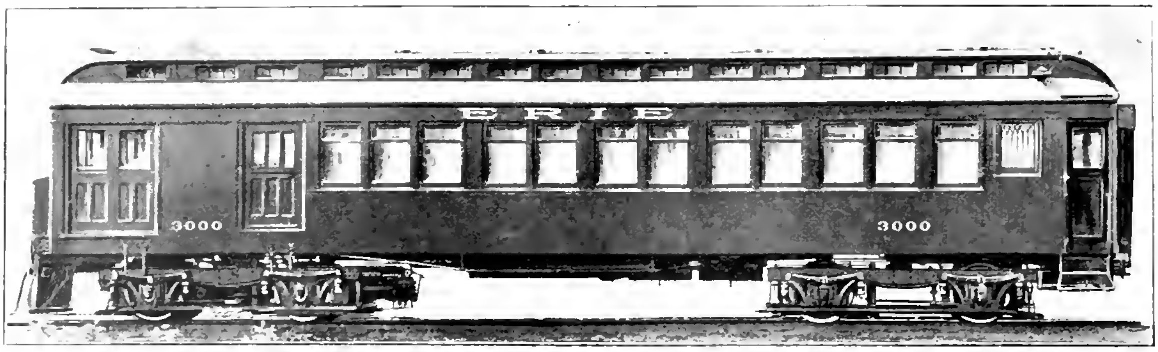
From a painter's standpoint is pressed fibre as durable as a three-ply wood veneer head-lining for passenger equipment? Discussion to be opened by O. P. Wilkins.

What should be the nature of a detergent for railway paint shop use? Discussion to be opened by B. E. Miller.

Mr. A. P. Dane, Reading, Mass., is secretary of the association and should be addressed for all information concerning the convention.

CONVENTION OF THE INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.

The fifteenth convention of the above association will be held in Montreal, Canada, August 20 to 22. The Bath Hotel has been selected as the headquarters and a rate of $2.50 per day for each person has been secured. The subjects which will be discussed at this meeting, together with the chairman of the committees, are as follows: "Flue welding," John Conners. "Tools and formers for bulldozers and steam hammers," G. M. Stewart. "Piece work," Grant Bollinger. "Discipline and classification of work," S. Uren. "Case hardening methods, time taken and samples," Geo. Masser. "Best fuel for use in smith shop," Jos. Jordan. "Frame making, either steel or iron; also repairing frames," Grant Bollinger. "Thermit welding," Geo. Kelly. "What can each member do to increase the usefulness of the association," G. F. Hinkens.



120 HORSE-POWER GANZ STEAM MOTOR CAR—ERIE RAILROAD.

GANZ STEAM MOTOR CAR.

ERIE RAILROAD.

The Erie Railroad during the past few weeks has had in operation on one of its suburban lines near New York a Ganz steam motor car, which is shown in the accompanying illustrations. This is the first car of this type to be constructed in this country and was built at Dayton, O., by the Railway Auto Car Company of New York, which company controls the Ganz patents on this continent.

In brief, the car consists of two compound enclosed steam motors of 60 h.p. each, which are mounted on the forward truck and drive the axles through gearing. In the forward end of the car above the truck is a steam generator which furnishes superheated steam at 270 lbs. pressure for the motors.

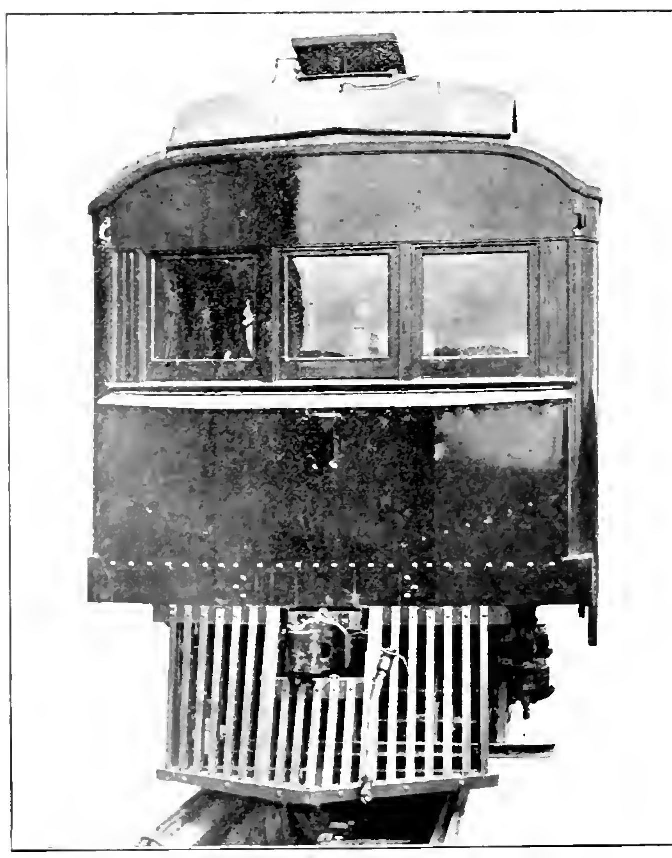
The car body is of wooden construction and in exterior appearance is very similar to a composite passenger and baggage suburban car. It measures 58 ft. over all and seats 50 passengers. The compartment at the forward end is 6 ft. long and contains the steam generator with its accompanying pumps and also the control apparatus for the motors, engineer's brake valve, etc. The fuel, which is either anthracite coal or coke, is carried in a bunker in the forward end of the car projecting out beyond the car body and arranged to be filled from the outside. This bunker will hold enough coal for a continuous run of 50 miles. Just back of the generator room is a 6 ft. compartment for baggage, behind which is a smoking compartment to seat 12 passengers. The remainder of the car is a general passenger compartment. This car weighs 45 tons in working order. It will be remembered that the car which is being built by this company for the Chicago, Rock Island & Pacific Railway (see AMERICAN ENGINEER AND RAILROAD JOURNAL, April, 1907, page 141) weighs but 26 tons and is of approximately the same size. This difference in weight is due to the fact that the Rock Island car is to be of all steel construction, while the Erie car has a wooden body.

The steam motors have cylinders 4.7 and 6.7 x 5.5 in. and are arranged so that either can be operated independently or both work together. The maximum tractive effort is 3,700 lbs. They are completely enclosed in dust proof cases, which are partially filled with oil so that all moving parts receive continuous and thorough lubrication. The cylinders are steam jacketed and the motors are to be operated at a normal speed of 600 r. p. m., although they will run satisfactorily up to 900 r. p. m. A by-pass valve is provided for admitting high pressure steam to the low pressure cylinder to increase the tractive effort at starting or when otherwise necessary. The motors are hung from the frame of the truck by spring suspension, the steam connections to the generator being flexible. Universal joints are fitted to all of the operating rods for controlling the motors. There is an intermediate shaft interposed between the crank shaft and the driving axle which carries three gears, one being in permanent engagement with the gear wheel on the axle, and the other two being fitted with friction clutches. These are of different diameters and can be thrown in one at a time, one combination giving full gear and the other half gear speed.

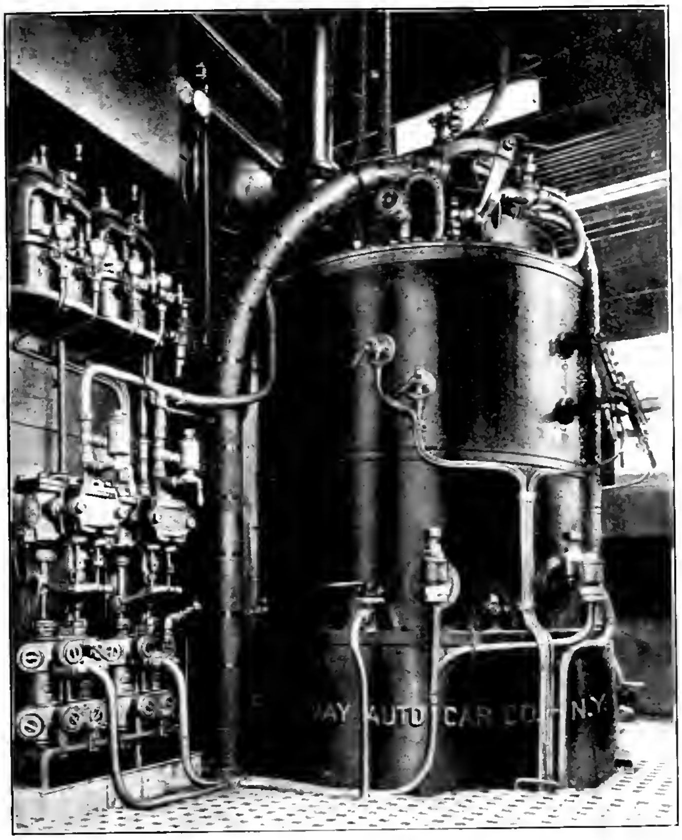
One of the illustrations shows the all steel truck which carries these generators. This truck is specially designed for this purpose and is practically identical with the trucks used on the Ganz cars abroad.

The steam generator is 42 in. in diameter and 5 ft. high. It is of the water tube non-explosive type and consists essentially of four steel cylinders arranged concentrically. The spaces between the two outer cylinders and the two inner ones form the water legs of the boiler and these two spaces are connected by a large number of small tubes which constitute the bulk of the heating surface of the boiler. The water level is below the upper tubes and hence these act as a superheater. The total amount of water in the boiler is comparatively small and a continuous feed is provided from the pumps. This boiler has a heating surface of 212 sq. ft. and a grate area of 6 sq. ft. It is rated at 120 h.p., delivering the superheated steam at 270 lbs. pressure. It is claimed that steam at this pressure can be obtained in from 20 to 30 minutes from cold water, using either coke or anthracite coal.

Provision has been made for easily exposing the tubes for cleaning and the boiler is provided with a patented construction at the mouth of the feed pipe by means of which the feed water assists in cleaning out any mud that clings to the tubes. The water supply is carried in a tank of 600 gal. capacity built in the underframe of the car.



VIEW OF GANZ MOTOR CAR SHOWING COAL BUNKER



STEAM GENERATOR—GANZ MOTOR CAR.

The air brakes are of the Westinghouse type, the air compressor being mounted on the trailer truck and driven from one of the axles of the truck. Lighting is by Commercial acetylene gas and the car is heated by steam.

This car is designed for a speed of 40 miles per hour on the level and 15 miles an hour on two per cent. grades and will haul a trailer at a speed of 30 miles per hour on a level track. In a recent trial trip a speed of 45 miles an hour was maintained.

PERSONALS

Mr. S. J. Merrill has been appointed master mechanic of the Union Pacific R. R. at Denver, Colo.

Mr. Albert T. Van Antwerp, master carpenter of the Pennsylvania Railroad at East Aurora, N. Y., died June 16. Age 65 years.

Mr. W. S. Kenyon has been appointed master mechanic of the fourth division of the Denver & Rio Grande R. R., with headquarters at Alamosa, Colo., vice Mr. G. W. Mudd, resigned.

Mr. William Baird has been appointed general car inspector of the Chicago, Burlington & Quincy Lines west of the Missouri River, with headquarters at Lincoln, Neb., vice Mr. E. S. Barstow, resigned.

Mr. W. J. Wilgus, vice-president of the New York Central & Hudson River Railroad, who has been in charge of the electrical installation from its inception, has tendered his resignation to take effect October 1.

Mr. W. O. Thompson, assistant superintendent of motive power of the R., W. & O. division, has been appointed master car builder of the New York Central at East Buffalo, to succeed the late James Macbeth.

Mr. H. C. Manchester, master mechanic of the Boston & Maine R. R. at Mechanicsville, N. Y., has been appointed assistant superintendent of motive power of the Maine Central R. R., with office at Portland, Me.

Mr. D. D. Robertson has been appointed master mechanic of the Lehigh Valley R. R. at Sayre, Pa., succeeding Mr. A. C. Adams, resigned. Mr. Robertson was until recently general master mechanic of the Fort Worth & Denver City Ry.

Mr. W. H. Chambers, assistant master mechanic of the Denver & Rio Grande R. R. at Helper, Utah, has been appointed to the new office of master mechanic of the Denver & Rio Grande R. R., the Rio Grande Western Ry. and the Colorado Midland Ry. Headquarters at Grand Junction, Colo.

Dr. W. F. M. Goss, dean of the school of engineering at Purdue University, has resigned to accept the deanship of the engineering schools of the University of Illinois. Dr. Goss has been at Purdue since 1879, when he organized the department of which he has since been the head. He is a graduate of Massachusetts Institute of Technology.

Mr. James Macbeth, master car builder of the New York Central at East Buffalo, died on July 5 at his home in Buffalo, N. Y. Mr. Macbeth was born in Aberdeen, Scotland, and began railroad life in this country in 1859 as an apprentice in the machine shops of the Great Western Ry. of Canada. He had been in the position he held at the time of his death since 1893. Mr. Macbeth was a charter member of the Central Railway Club.

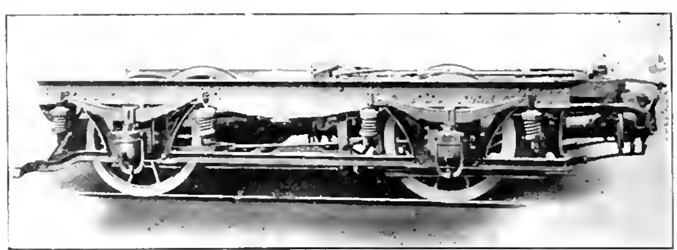
BOOKS

Proceedings of the American Railway Association Meeting, held in Chicago, April 24, 1907. W. F. Allen, secretary and treasurer, 24 Park Place, New York City.

This copy of the proceedings contains a list of the members of the association, together with a list of the members of the many committees of the association. It includes complete reports of all the committees, together with the discussions thereon. An appendix is included, giving a report of the car hire meeting held on November 9, 1906, and the informal conference of owners and users of cars held on April 22, 1907.

Railroad Men's Catechism. By Angus Sinclair. Bound in Cloth. 216 pages. 4¼ x 6½ in. Illustrated. Published by the Angus Sinclair Publishing Company, 136 Liberty Street, New York. Price, $1.00.

This book includes, in catechism form, a large amount of information which will be useful to all classes of railroad men. The questions cover the entire practice of train operating and explain all details of mechanism. The basis of the questions used in this book are a series prepared for the examination of engineers and firemen employed on one of the leading railway systems. To these have been added many others, including the 20 questions and answers on the standard code of the American Railway Association. A section on mechanical calculations has also been added. The book is illustrated where necessary and will be found to fulfil its purpose in a very satisfactory manner.



TRUCK—GANZ STEAM MOTOR CAR.

Forty Thousand Dollars a Day for New Equipment.—According to figures recently compiled in the New York office, the Harriman Lines have been spending an average of $40,000 a day for new equipment during the past five years.

MASTER MECHANICS' ASSOCIATION.

FORTIETH ANNUAL CONVENTION.

ABSTRACTS OF REPORTS AND INDIVIDUAL PAPERS.*

Locomotive Failures, Records, and the Results of Keeping Them.

INDIVIDUAL PAPER BY W. E. DUNHAM, M. M., C. & N.-W. RY.

The failure of an engine in service interests so many of the various departments of a railroad directly or indirectly, as well as the traveling or shipping public, that every effort is bent toward avoiding them. Shortage of power at times may compel the use of engines on the road which, under ordinary circumstances, would be held for repairs. These engines should not be expected to handle full tonnage, but should be favored to a degree determined by the master mechanic in charge. But, on the other hand, no engine should be permitted to start on a trip unless the roundhouse foreman is practically sure that the engine will make the trip successfully if it is handled properly and not delayed unreasonably. Also an engine crew should be given as much consideration as engines. They cannot work continually on short hours of rest unless their working hours are also made short.

It is natural during a rush period, whether of long or short duration, that engine failures should increase in number and often in proportion to the total miles run in a given period of time. Such results, however, may be due more to the operating methods and conditions than to any lack of attention on the part of the roundhouse forces. Under these circumstances the division as a whole should be held responsible, instead of the motive power department alone being charged with a failure.

There exists at the present time on American railways no uniform method of recording engine failures. This is due to several causes, chief among which is the fact that what would be considered an engine failure on one road would not be on another. A complete file of what constitutes engine failures would contain as many definitions, almost, as there are railroads.

A failure is the result of ineffectual efforts to accomplish a desired end. The desires of the railway train service are: to keep all trains moving promptly; to leave the starting terminal on time; to make all meeting points; to make all junction connections; to avoid delays to other trains, and reach the destination on time. A failure should therefore be charged to an engine when through some fault of the roundhouse, the engine or the engine crew, the train fails to meet these expectations. But let us suppose that a delay does occur as the result of a defect in the engine, but at the same time all meeting points and junction connections are made and the train departs and arrives on time. Should a failure be charged? Would not a record of a delay answer all the purposes? An engineman hates to be responsible for a failure, but he takes pride in being able to make up for all delays for which he or his engine are the cause.

Any set of rules for making engine failure records should be lenient, in a measure, to both the mechanical and transportation branches of the operating department. Reasonable leeway should be given on both sides. Experience is the best guide as to how much this leeway should be and experience also is the best guide as to what an engine should be charged with. Considering all parties directly interested a fair statement of what constitutes an engine failure might be as follows:

First. A delay waiting for an engine at an initial terminal constitutes an engine failure, excepting in cases where an engine has to be turned and does not arrive in time to be dispatched and cared for before leaving time.

Second. A delay at a terminal, a meeting point, a junction connection, or to other traffic, or a reduction of tonnage due to an engine breaking down, not steaming well, running hot or any defect in the engine, constitutes an engine failure.

Under these rules the following can, with justice to all concerned, be considered as not constituting engine failures:

1. Delays to passenger trains when they are five minutes or less late at terminals or junction points.
2. Delays to scheduled freight trains when they are twenty minutes or less late at terminals or junction points.
3. Delays to extra dead freight trains if the run is made in less hours than the miles divided by ten.
4. Delays to fast schedule trains when the weather conditions are such that it is impossible to make the time, providing the engine is working and steaming well.
5. Delays when an engine loses time but afterward regains it without delay to connections or other traffic.
6. Delays to a passenger or scheduled freight train due to other causes, and the engine (having a defect) makes up more time than it loses on its own account.
7. Delays when an engine is given an excess of tonnage and stalls on a hill, providing the engine is working and steaming well.
8. Delays when an engine gets out of coal or water caused by being held between coal or water stations an unreasonable length of time.
9. Delays due to engines steaming poorly or flues leaking on runs where the engine has been held on side tracks for reasons other than the defects of engine, or on the road an unreasonable length of time; say fifteen hours or more per one hundred miles.
10. Reasonable delays for cleaning fires and ash pans on the road.
11. Delays caused by breakage of some part of the engine due to sticking obstructions on or beside the track.
12. Delays due to broken draft-rigging on engine or tender caused by air being set on the train on account of burst hose or break-in-two.
13. Delays to an engine coming to the shop for repairs when it is hauling full tonnage.
14. Delays caused by an engine being held in the roundhouse for needed repairs and called for by the operating department, although they have been informed that the engine will not be ready until a stated time.

Any system of engine failure reports must start with the advice received from the engineman by the dispatcher. This should include sufficient information to show whether the boiler, the machinery or some of the special attachments are troubling, and, if possible, give a brief detail of what is wrong. The dispatcher then should advise the master mechanic, or the division foreman and also the road foreman and the local foreman of the terminal toward which the engine is headed. Upon the arrival of the engine the roundhouse foreman or his representative should make a personal and close examination and prepare a statement, which he forwards to the master mechanic along with the engineman's written explanation. These papers will give the master mechanic full knowledge of the case and they should be in his hands within twenty-four hours after the failure occurs. This prompt action is of particular value in connection with failure reports, convincing all concerned that things are being watched and checked closely.

With a view to having uniformity in their reports and saving time, blank breakage report forms, printed in copying-ink, can be used. These reports should first be checked by the local master mechanic and shop foreman and then passed on to the assistant superintendent of motive power, who in turn sends them to the mechanical engineer for final checking and filing.

CHICAGO & NORTH-WESTERN RAILWAY COMPANY.

Div. MOTIVE POWER AND MACHINERY DEPT. *190*

To .... *M. M.*

Engine No. *Train No.* .... *Date* *Departed from* ....

at *M. Arrived at* *at* .... *M.*

Enginemen will fill out one of these forms for each trip, giving each delay of **THREE** minutes or more from whatever cause, and state the cause of each delay.

PLACE DELAYED	TIME DELAYED	STATE CAUSE OF DELAY AFTER EACH POINT	MADE UP TO STATION	TIME IN MINUTES
Delayed leaving		*Signed,*		
Late arriving				*Engineman.*

ENGINEMAN'S DELAY REPORT.

*Continued from page 278, July number.

CHICAGO & NORTH-WESTERN RAILWAY COMPANY.

.... Division.

Report of Engine Failures, for ten days ending , 190

INSTRUCTIONS.—Three of these reports must be made each month. The first to include all failures from the 1st to 10th, inclusive; the second, 11th to 20th, inclusive; and the third, 21st to and including the last day of the month. They should be forwarded not later than three days after termination of period which they cover. *Actual* cause of failure must be shown.

DATE OF FAILURE	ENGINE NUMBER	TRAIN NUMBER	ENGINEER	TOTAL TIME DELAYED	TIME MADE UP	CAUSE OF FAILURE AND REMARKS

DIVISION REPORT OF ENGINE FAILURES.

Upon the accuracy and detail of these first papers depends the full value of the failure records. As a further check upon the work performed by the engine, a delay report can be made out by the engineman for each trip. An outline of this form is shown. Frequently by following back a few days and noting the performance of the engine as shown by these reports the real cause for the final failure can be found. A good supplementary report in this same connection is one of a similar character made by the conductor to the division superintendent.

After a full examination and investigation of each failure a monthly division report should be made by the master mechanic to the superintendent of motive power. A more frequent report of this kind is often advisable, for instance, once every ten days. These reports can then be compiled in the superintendent's office, a statement being made which classifies and details the failures and also shows totals for each division or terminal of the railway.

Any system of reporting engine failures should have for its sole aim the improvement of the service by giving information as to what is causing trouble. This requires accuracy, as previously mentioned. There is a natural tendency for enginemen to be rather cautious about sending telegraph reports of defects or troubles on snap judgment as well as a similar tendency for a dispatcher to be inclined to blame the engineman or the engine for being the primary cause of a train delay. These active representatives of two branches of the operating department are the men who can do the most toward reducing engine failures by keeping in close touch with each other when on duty and by giving all the facts in a plain and full manner when trouble does occur. If the failure is due to long hours on the road the information is of value to the superintendent, who can determine the necessary action for increasing the speed of the train or trains. From these same records his attention is forcibly brought to the results of inferior coal, poorly designed and operated coaling stations, scanty and bad water supplies, overloading of engines, indifferent train-dispatching, lack of harmony in action on the part of the men in charge of the trains.

To the mechanical department officers these reports are particularly valuable. In connection with the same records made by the shops, they show up poor designs, weak parts, inferior material, bad shop practices, careless handling, indifferent inspection and poor workmanship. The local master mechanic and shop foreman make the first use of these reports as they receive them. Inspection of the broken or defective part, together with the report of what occurred, gives them the best possible line-up as to what is necessary to prevent a repetition. Their investigation should be carried to a finish and the exact cause found.

The full report then goes to the next higher officer, usually the assistant superintendent of motive power. Here it is checked and by the frequency of similar reports, attention is drawn to some particular defect. It may be some type of cylinder head, rod strap, eccentric or any such part of the machinery of a certain class of engine that is giving particular trouble. Or it may be a certain make of boiler will not stand up to the service. These reports quickly show these defects to those who are in charge of such matters. The detail can then be quietly and efficiently remedied without the necessity of any further investigation. Such, generally, is the case if some shop or shops are at all careless in preparing the work or are passing as good enough, parts that are not true to dimensions or shape, or material designated.

When the assistant superintendent of motive power is through with his investigation the reports should go to the mechanical engineer. He should check the dimensions and shape of the broken piece. As the result of his analysis data are obtained for use in future designs either for new parts to take the place of defective ones or for preparing plans for new engines. It shows to him where modern shop practices and road service have found the weak spots in older types of engines. Steps are then taken through the proper channels to discard the troublesome member and substitute as fast as possible a modern design. Concrete examples of instances where such a system of reports has resulted in improvements to the service and cost records would approximate a complete history of nearly all our modern improvements.

There is no doubt as to the merits of such a system of failure reports as outlined, in the minds of those who have followed it carefully and consistently. With our railway systems spread over a large territory and divided up into small sections for operating and mechanical attention, it is absolutely necessary that some general procedure such as this be followed. Also for the purposes of comparison between different lines it is to be hoped that some standard agreement can be reached for recording and classifying engine failures.

Causes of Leaks in Locomotive Boiler Tubes.

INDIVIDUAL PAPER BY M. E. WELLS, A. M. M., WHEELING & LAKE ERIE R. R.

For convenience of discussion, the subject can be divided into two general heads: Leaks due to mechanical causes; Leaks due to variation in temperature.

MECHANICAL CAUSES.

The first can be divided into four subheads—first, defective work at the time of first setting the tubes. This, as a cause of tube leakage, is very slight, because almost any kind of a job done by an apprentice boy in the front end will hold from one shopping of an engine to the next; while a much better job done by a skilled mechanic gives practically no trouble, and really never causes a delay, when done on the upper tubes in the fire-box; and yet the most skilful job that it is possible for a skilled mechanic to do on the bottom tubes in the fire-box will hold, at most, but a few days, in our largest boilers.

The second cause under this head, that of poor hurry-up work in running repairs, is a much more prolific source of trouble than any one of the other mechanical causes, and yet the remedy is quickly stated—take time to do it well.

The third subhead is the possible cause of leaks on account of the vibration of the tubes. Much stress is put upon this by some, especially if long tubes are used. This vibration as a cause of leakage cannot be considered very important, because if it was this action would certainly loosen the very simple job of tube setting done in the smoke-box tube plate.

The fourth mechanical cause is the wearing out of the tube ends by the abrasive action of the cinders. This cause is suggested by the Northern Railway of France, and the same, or a similar condition, is referred to by the Pennsylvania Railroad, as "burnt-off and cracked beads, due to shallow fire-boxes." It will be shown later that the real cause of this condition is internal, rather than external, and that, really, it should be classified under the second general head, namely, leaks due to variations of temperature.

LEAKS DUE TO VARIATION OF TEMPERATURE.

Under this we have two subheads: causes of leaks due to equal variations of temperature, and those due to unequal variations of temperature.

It can be clearly demonstrated that small damage is done to boiler tube joints when they are subjected to equal variations of temperature; that is, tube ends, fitted in a tube plate, can be heated up and cooled down a great number of times, and not become loosened, if all connected parts are heated up and cooled down uniformly. This we have also learned in a practical way from the fact that the top tubes in a fire-box give practically no trouble from leaking, as compared with the bottom tubes, and yet these top tubes are subjected to slightly higher temperatures than the bottom tubes. The best proof of this we find in some tests made by the Chicago Great Western Railroad, and reported in the 1904 Proceedings of this Association. These show, conclusively, a hotter condition of the top tubes than of the bottom tubes. We must therefore conclude that the deterioration and leakage of the bottom tubes in the fire-box does not come from heat alone; the real secret being that we cannot keep the bottom tubes hot enough—or at least uniformly hot—on account of the cooling constantly taking place in the water space, due to the injection of feed water. Another significant fact in this con-

nection is, that the tubes never leak in the front tube sheet. The argument that it is not as hot seems, in the past, to have put an end to this discussion. And while this is so, yet it averages practically one-third as hot—and one case is reported where, on a narrow fire-box boiler with short tubes, the front end temperature ran up to one-half that of the fire-box—if there was really much action on the part of heat alone to loosen these joints, they certainly should be affected by this heat; but they are not loosened, even after months of service. And added to this, you have all seen the front ends of the tubes and the front tube sheet banked solid with scale, and still no leakage. If the bottom tubes in the fire-box leak at regular intervals—and this is, at the best, every four or five days—why should not tubes leak after months of service, subjected to one-third or one-half the temperature of the fire-box? We are, therefore, led to the conclusion that there are causes, other than the equal variations of temperature, that really cause most of the leaks in boiler tubes. This brings us to the last and most important division of our subject, that of leaks due to unequal variations of temperature.

* * * * * * *

I now want to draw your attention from this much-talked-of imaginary cause (cold air) to the two real and important ones, namely, leaks due to deposits of incrustation, and those due to unequal variations of temperature produced by the varying water temperatures, especially those caused by the injection of feed water. These are the two great causes of all boiler leakage, and the two lines along which much improvement is yet possible. A most important line to work along is the improvement of feed water, and yet good judgment must be used to guard against transforming a fairly good hard water district into an alkali district, that will give you so much foam that you cannot pull cars. The benefits derived from a decrease of incrustation is beyond question; but when we must trade lime for soda there enters one of the most difficult problems that to-day confronts the railroad chemist. How much soda can we afford to take for the advantage of getting rid of a certain amount of incrusting water? The question should be carefully worked out for each operating district as a whole, before anything is done toward spending money for plants. (At this point the author introduces the formulæ of some home-made anti-incrusting compounds that have been in constant use for years past, and are still in use, on European and other railways. They are taken from the Proceedings of the International Railway Congress.)

* * * * * * *

This brings us to the subject of leaks produced by the unequal variations of temperature in the water space. So much has already been said and published along this line that we will merely refer you again to tests showing the effects of injudiciously injected feed-water as a cause of leaks, as reported in the 1904 Proceedings of this Association (pages 231 to 241) by the Burlington Railroad. There is scarcely a trip made by any of your enginemen but what, in most cases, it is dependent upon the crew as to whether they are delayed or not by leaky tubes. It is so important a factor that they should receive all the education possible along this line.

While the education of enginemen is a most important line to work along, yet I believe the members of this Association should be bending their energies along the line of changing the method of feeding, or using warmer water with which to feed, their locomotive boilers. If the temperature of the water entering boilers could be raised to a temperature corresponding to the maximum steam pressure, or if it could be heated to this same temperature after entering but before being liberated in the boiler proper, our boiler troubles would be wonderfully reduced, even when using average feed-water, because, as I have said before, our trouble is from cold water and not from cold air or burned tube ends and side sheets. I sometimes think that the prevalence of the cold air idea has come from the fact that almost every locomotive boiler ever built has had the fire door on a line with the bottom tubes, and, in shallow fire-boxes, on the line of most of our side sheet troubles; and, for want of better knowledge, we got into the habit of saying it was cold air, and the habit, like all other habits, is hard to change. I have had experience with large locomotives in the West which, on account of burning lignite coal and to reduce spark throwing, had very large arches fitted and cemented perfectly tight against the tube sheet, so that every particle of fire and gases had to come back and go over the top of the arch before reaching the tubes. The bottom tubes in these boilers leaked, just as they do in any other boiler, and yet these bottom tubes were practically as free from the effects of so-called cold air as were the front ends of these same tubes.

The best information received on fire-box and front end temperatures is the following from the Pennsylvania Railroad, in answer to two of the questions sent out:

"When a boiler is being worked the hardest, what do you find the temperature of the fire in the fire-box, or at the back end of the tubes, to be? When burning 130 pounds of coal per square foot of grate, there is a temperature of about 2,300° (see Locomotive Tests and Exhibits, Pennsylvania Railroad, St. Louis, 1904, pages 695 to 699). With an Atlantic type of locomotive on the testing plant, when burning 168 pounds of coal per square foot of grate per hour, a temperature of 2,415° was obtained.

"When a boiler is being worked the hardest, what do you find the temperature in the smoke-box or front end of the tubes to be? For freight locomotives as developed at St. Louis, 574° to 757°. For passenger locomotives tested, 594° to 787°."

The temperature of boiler plates averages about 75° hotter than the water in the boiler. In fact, this is high, because for years soft plugs have been used filled with 450° F. metal; and this is but 62° above the temperature of a boiler carrying two hundred pounds of steam.

Along the line of doing something to overcome the bad effects of injected feed water—and this is what I want, especially, to interest you in—the London & Southwestern Railway of England sends us the most interesting report received: "We have given up the use of injectors. When injectors require renewing they are replaced by duplex pumps for feeding the boiler with hot water, heated by exhaust steam passing through steel tubes in the water tanks. I should think this would be a great advantage to your boilers. Our practice is to start the pumps when we start the train from a terminal station, and keep them constantly at work until stopping. This constant feed prevents any rapid difference in the temperature of the water in the boiler. We pass our feed water through the smoke-box so that when it enters the boiler it is up to the same temperature. We mark the gauge glass giving the maximum and minimum height of water feed; our variation is one-half." This road in another part of its report says: "We have little or no trouble with leaky tubes; and not such as to require attention between trips."

I hope you will get an inspiration from what this English road is doing, and do something along the line of feeding your boilers with warmer water, or at least feed it into the boiler in such a manner that a low temperature water cannot settle and circulate through the back ends of the bottom tubes and around the bottom of the fire-box sheets, thereby causing most of your boiler troubles. If I can impress this Association with the fact that a very large per cent. of their tube and fire-box troubles would be over if they could only stop the destruction that is going on from this one agency alone, I shall feel that this paper has not been in vain.

Mechanical Stokers.

Committee—Wm. Garstang, chairman; D. F. Crawford, J. F. Walsh, G. F. Hodgins.

Since the last convention, trials of the Day-Kincaid, Hayden and Krouse automatic stokers for locomotives have been continued by various railroad companies. The data obtained from these tests are not, as yet, in sufficiently conclusive shape to make it desirable to present them to the Association.

Your committee has advice that one of the larger railroads in the country has prepared designs of two types of experimental stokers, the test of which, it is expected, will be started at an early date.

Development of Motor Cars for Light Passenger Services.

Committee—H. F. Ball, chairman; F. T. Hyndman, W. R. McKeen, Jr., L. R. Johnson, G. W. Wildin.

GASOLINE MOTORS—MECHANICAL TRANSMISSIONS.

Union Pacific.—In this country, the most extensive development work in the rail motor car field has been done by the Union Pacific Railway. To date, that railroad has built nine gasoline motor cars, all of which have direct mechanical drive.

Their latest design of car, motor car No. 8, is equipped with a 200 h.p. motor, especially built for the rough service incident to that of suburban lines. The motor consists of six cylinders, 10 inches diameter by 12 inches stroke. The total weight of the car is 61,300 pounds, equivalent to practically 300 pounds weight per 1 h.p. This car has, since last summer, been running regularly between Beatrice and Lincoln, Nebraska; it has shown remarkably uniform results and has materially increased the traffic between those two towns. Ten additional cars, similar to this successful model, are being built, as well as a number of trailers to be used in connection with them. Four regular branch line services have been maintained in Kansas and Nebraska, on the Union Pacific Railroad alone, during the severe weather conditions of the past winter, and with notable success. The motor cars have been remarkable in regularity of service, having demonstrated that they are even superior, in this respect, to the steam train service.

After two years of continuous service, it has been found that the average cost of fuel the year around, taking into consideration both summer and winter conditions, using 72 degree gasoline, amounts to 3.5 cents per car-mile. As a substitute for gasoline, California distillate has been used in regular service with gratifying results. Obviously, the cost per car-mile is thereby greatly reduced, as the distillate is a much cheaper product than gasoline. Some interesting experiments have been conducted with the motor of car No. 8, using denatured alcohol as fuel.

The results were very satisfactory, in fact the newest type of motor (No. 8) gives equally as good performance with that fuel as with gasoline.

"Sunny Brook."—A light railway motor car, the "Sunny Brook," has recently been built at Indianapolis, Ind., for service in Yellowstone Park. This car has a four-cylinder gasoline motor, cylinders 6 by 6 inches, the engine developing 50 h.p. at 700 r.p.m. The car is built after the conventional street car design and weighs 30,000 pounds.

GASOLINE MOTORS—ELECTRIC TRANSMISSION.

Strang Cars.—Another example of gasoline rail motor cars in successful operation is the Strang car, mentioned in last year's report. Three of these cars are in regular operation between Kansas City and Olathe. The first one has been in continuous service for over a year, the second and third cars having been in operation between six and seven months. Other cars of this type are now under construction for use on several steam roads. The transmission used in the Strang system is of the electric type, the generator being direct connected to the motor, forming a self-contained generating unit. Directly from the brushes of the generator, main wires lead to a controller of the series parallel type. From this controller, wires lead to electric motors hung on the axles of the front trucks according to standard electric railway practice. In multiple with the wires between the generator and controller, is connected a small storage battery, and in one of the main wires between the battery and the generator is placed a rheostat, which is used for the purpose of temporarily converting the generator into a motor when starting the engine. The first of the above-mentioned cars * weighs 78,000 pounds, and it is claimed that the gasoline consumption has averaged about .45 of a gallon of gasoline per motor car-mile for a mileage of 60,000 miles. The largest and latest of the three cars † above mentioned is 52 feet 9 inches long, weighs 84,000 pounds and has the following equipment: 100 h.p. gasoline engine, 50 kw. generator, two 65 h.p. motors and storage battery of 112 cells, with 250 a.h. capacity.

St. Joseph Valley Traction Company.—The motor car used on this road was in actual daily service for two years. Within the past two months, the equipment was destroyed by fire. The service of this car consisted in hauling from one to three trailers, three round trips per day, over a road eleven and one-half miles in length, making the half trip in thirty-five minutes with four stops, the heaviest grade being one and one-half per cent. It is stated that the fuel consumption with one trailer was three-fourths of a gallon per mile.

General Electric Company Car.—This company is now bringing out its second-rail motor car of the gasoline-electric type. The car body is of steel, the ends being rounded to decrease wind resistance. The roof is of the Mann type, equipped with globe suction ventilators. The car body is divided into an engine compartment, baggage, smoking, main and toilet compartments, and operating-cab at rear end. It has a seating capacity of forty.

The equipment consists of an eight-cylinder V construction gasoline motor of 150-175 h.p., direct connected to an eight pole, commutating pole, 90 kw. generator with an exciter of 3½ kw. capacity, for the purpose of exciting the fields of the main generator, and effecting the variable potential control. From the generator leads are conducted to two 65 h.p. motors, situated one upon each truck of the car. These motors are always connected in parallel, the required torque or speed being obtained by varying the field current of the generator through the intermediary of a specially constructed controller, embodying essentially the required resistance suitably arranged in fifteen steps.

The gasoline motor is of the four-cycle type, equipped with two separate systems of ignition. The carbureter is of the single-nozzle hand-compensated type, gasoline being supplied to it by means of a diaphragm pump. Radiators for water cooling are located on the roof of the car. The circulation is by thermo syphon. The gasoline motor is controlled by one lever superimposed over the controller handle. The normal speed of motor is 550 r.p.m. The car is heated by by-passing as much as required of the exhaust gases through pipes approximately in the same position as steam pipes in the standard railway coach. An acceleration of a mile per hour per second is obtained to approximately 25 to 28 miles per hour. From this point, acceleration falls off gradually until full speed is attained at approximately 50 to 55 miles per hour. The total weight of the car is 60,000 pounds.

STEAM MOTORS.

Canadian Pacific.—In the steam motor car field, one of the noteworthy examples of original development work is found in the car designed and built by the Canadian Pacific Railway.‡ This car was in operation all of last summer between Montreal and Vaudreuil, a distance of twenty-four miles, giving a service of three round trips per day, on a regular schedule, allowing one hour for the run out, including twelve stops, and the same on the return trip. It was popular with the passengers and gave fairly good satisfaction to the railway company.

* See AMERICAN ENGINEER, March, 1906, page 103.

† See AMERICAN ENGINEER, Sept., 1906, page 362.

‡ See AMERICAN ENGINEER, Aug., 1906, pp. 294, and Sept., 1906, pp. 331.

When the car was first put into service, 1.8 imperial gallons of oil were consumed per mile, but as the men gained experience in the handling of machinery, the consumption was reduced to 1.6 imperial gallons per mile; 5,000 gallons of water were evaporated per hour, giving a factor of one pound of oil to ten pounds of water. Experiments have recently been made on the testing plant at the Canadian Pacific shops with the same boiler and motor, using ordinary run of mine coal as fuel, instead of oil, with very satisfactory results.

Ganz Cars.—Motor cars of this type are being built for four different roads.* All-steel construction is used for the body, which has a seating capacity for fifty-two passengers. Total weight of car in working order is 70,000 pounds. This car is designed to maintain a speed of thirty-five miles per hour on a level track. Average fuel consumption is claimed to be from ten to twelve pounds of coal per mile.

MOTOR CARS ABROAD.

The development of motor cars abroad has made greater strides than in this country. Numerous English and Continental railway companies have permanently established rail motor car service in different localities with marked success. One may see such cars in operation on unimportant branch lines as feeders to trunk line trains; on main lines through thickly populated districts carrying passengers to and from more important towns served by express trains; on suburban lines in competition with trolley cars and steam trains and on an entire railway system where there is no other means of transportation except for heavy freight.

A brief description of the motor cars in operation on the principal railways of England and the Continent is given herewith, which will serve to show the developments of this type of motor car abroad. It is not the purpose of this report to enter minutely into the details of construction, but rather to show up in a general way the present situation.

GASOLINE MOTORS—MECHANICAL TRANSMISSION.

German Daimler Car.—The German Daimler gasoline car has been used in considerable numbers on some of the smaller German railways, notably the Wurtemberg State Railway and on the Swiss Federal Railway. It is a comparatively small car, having a total length of 33 feet, with a seating capacity of thirty-six. It is equipped with a 30 h.p. Daimler engine of the heavy, slow-speed type, its normal speed being about 550 r.p.m. The motor has four cylinders 5¼ inches diameter by 6¾ inches stroke. It is located in the middle of the car, attached to a subframe upon which the car body is supported by eight elliptic springs, the subframe being carried rigid on the two axles. Power is transmitted from the motor through a leather-faced cone friction clutch, and through a sliding gear transmission (arranged to give four speeds and reverse) to one of the axles. Control levers are provided at each end of the car, by means of which the speed of the motor, or the direction of motion, is controlled from either platform.

GASOLINE MOTORS—ELECTRIC TRANSMISSION.

North-Eastern Railway Car.—About three years ago, the North-Eastern Railway of England put into service two "petrol-electric" cars. The power plant consists of a four-cylinder horizontal opposed Wolseley gasoline engine † (8½ x 10 inches, 85 b.h.p. at 420 r.p.m.) direct connected to a compound wound, separately excited generator, of 55 kw. capacity, which furnishes current to two 50 h.p. electric motors, of the ordinary railway type, on the leading truck. The total weight, including 60 gallons of gasoline and about 100 gallons of cooling water, is 35 tons, of which 22 tons are carried on the power truck. These cars are used during the summer season only. Three and one-half car-miles per gallon of gasoline is claimed for them. As this particular type of car has not been perpetuated by the original builders and users, it is safe to assume that it is not entirely satisfactory. The enormous size and weight of the power plant and the space occupied (being about one-third the total length of the car), are undoubtedly the reasons for discontinuing the construction of this design.

Arad & Csanadar Railway.—On the Arad & Csanadar Railway, in Hungary, a number of gasoline electric cars are used, the largest of which has a 70 h.p. gasoline motor direct connected to a 45 kw. generator, which supplies current to ordinary railway type motors attached to the two axles. The space occupied by the power plant is considerably less in proportion to the length of the car than that of the North-Eastern Railway, although the systems are practically identical in principle. The acceleration of the car is very good. Its maximum speed is about thirty-five miles per hour without trailer. It is claimed by engineers of this road that sixty-five per cent. of the motor's power is delivered at the wheels. Very satisfactory results are reported from these cars.

STEAM MOTORS.

Great Western Railway of England.—One of the most satisfactory cars in operation abroad at the present time is the one

* See AMERICAN ENGINEER, April, 1907, page 141, and this issue.

† See AMERICAN ENGINEER, Mar., 1906, page 88.

developed by the chief engineer of the Great Western Railway of England. In the neighborhood of sixty of these cars are in service on various parts of the Great Western System, and others are in course of construction. They combine to a remarkable degree many of those qualities essential to success, namely, large seating capacity with only moderate weight, flexibility of control, reasonable speed and acceleration, reliability, low maintenance and fair operating costs.

The boiler is of the vertical, fire-tube type with no superheater, supported directly on the frame of the power truck and serving as a center pin by transmitting the driving effort to the sills of the car through flat springs. It is enclosed within a compartment of the car body (about 14 feet long), which contains coal bunkers, operating levers, etc. As the car is arranged to run in both directions and controlled from both ends, a stoker is employed in addition to the driver. Aside from attending to the fire, it is his duty to regulate the cut-off when the driver is at the other end of the car, as only brake and throttle connections are provided there.

The motor consists of two single-expansion cylinders, 12 x 16 inches, coupled direct to the rear driving wheels, which in turn are coupled to the front drivers. Walschaert valve gear is used. The water supply is carried in tanks hung beneath the car body midway between the trucks. A maximum speed of fifty-five miles per hour can be obtained, although the average running speed is from thirty to thirty-five miles per hour. Their maximum acceleration is about one mile per hour per second.

Taff-Vale Railway.—The Taff-Vale Railway has built a number of cars for its own use* and for other railways, being similar in design to the Great Western car, the chief difference being in the construction of the boiler.

Lancashire & Yorkshire Railway.—The Lancashire & Yorkshire Railway† has cars similar to the Taff-Vale, in that the forward end is pivoted on the power truck. The boiler is of the usual locomotive type with horizontal fire tubes. This engine is practically a small locomotive with drivers coupled.

Ganz System.—Ganz cars are used rather extensively in Central Europe in three sizes, 35, 50 and 80 h.p. at 260 r.p.m. The general arrangement is the same in all three, the boiler being placed in a compartment at the forward end of the car, together with fuel bunker, feed pumps and controlling apparatus. The motor is placed horizontally on the leading truck, and drives the rear axle through spur gears. It is supported in the usual electric railway motor style, one end heing swiveled above the axle, and the other supported elastically from the truck frame. The car is controlled from only one end and one man is required to operate it. The boiler consists of four concentric cylinders with headers (held in place by bolts) forming two annular water spaces joined together by means of slightly inclined steel water tubes, 25 mm. outside diameter and 2 mm. thick. Within the inner cylinder is another cylinder of slightly smaller diameter through which the fuel is fed to the grate below, the flame and hot gases passing around the water tubes to the stack. The motors are two-cylinder cross compound. The largest car, 80 h.p., weighs 23 tons, and is capable of climbing 1.6 per cent. grade, with two trailers weighing 12 tons each, at a speed of twenty-five miles per hour.

Purrey System.—The Paris-Orleans road has ten cars and twelve power trucks equipped with the Purrey system. This system has also been used for a number of years on different tramway lines in the city of Paris.

The Paris-Orleans cars have a total length of about 60 feet with a capacity of thirty third-class passengers in three compartments, and twenty-five first-class passengers in two and one-half compartments, and in addition there is a baggage compartment at the forward end 11 feet 6 inches long. The forward end is pivoted on the power truck, the rear end being carried upon a single axle. The total weight of this car is about 35 tons. The power truck which carries the boiler, motor, fuel, water, etc., has a 126-inch wheel base, the rear wheels only being used for driving. The Purrey boiler is tubular, consisting of two drums, the lower one of rectangular section and made of cast steel, the upper one cylindrical and of cast iron. The lower drum is divided into three compartments, two of which are provided for water, the third being for superheated steam. The outer and lower compartment is connected with the upper drum by two large return pipes. It is also connected with the intermediate compartment of the same drum by 41 U-shaped tubes. The feed-water entering the lower compartment is thus heated in passing through these tubes, which are in direct contact with the flame. From this point the water rises through a series of U-shaped tubes to the upper drum, and the steam thus formed is returned from the upper drum through a number of similar tubes to the third compartment of the lower drum, from which it is taken to the motor. The steam is highly superheated in these tubes, the average temperature of superheat being from 750° to 900° F. Coke is used for fuel, feeding automatically from a bunker attached to the side of the boiler, the supply being regulated by a vertical sliding door. The motor is a four-cylinder tandem compound, rated at 260 h.p. at 650 r.p.m. Ordinary D-type valves are used, operated through Stephenson link motion. In this design the motor is attached horizontally to the frame of the car and its power transmitted to the rear axle by two toothed chains of similar construction to the Renold and Morse silent type. As a rule, one or two trailers are attached to these cars, the average weight of the train being 50 tons. The fuel consumption of this train is about 21 pounds of coke per mile. The car is capable of maintaining a speed of about fifty-six miles per hour. The cost of operation per train-mile is about 7 cents.

Serpollet System.—The Serpollet system differs from the Purrey and Ganz types chiefly in that the boiler is of the flash type, and kerosene is generally used as fuel. A very high degree of superheat is obtained (reaching even 1,200° F.), which, together with the incrustation attending the use of more or less impure water, is conducive to the burning of tubes. The experience of the Paris, Lyons & Mediterranean Ry. with this type of car has been rather unsatisfactory, because of tube troubles, and the Purrey car is now being adopted in its place.

Komarek Car.—This car is used to some extent by the Austrian State Railway and several of its branches. This car is capable of running at a speed of 25 miles per hour on a level while hauling trailers comprising a total of 50 tons. The operating cost is said to be about 5 cents per train-mile (exclusive of the guard's pay) coal costing $3.25 per ton.

CONCLUSION.

That there is a field for the rail motor car cannot be questioned; its breadth at the present period being limited only by the development of the motor-car power equipment.

Steam, as a motive power, has always possessed the distinct advantage of flexibility of control as well as reliability.

The internal combustion motor within certain defined limits of horse-power sizes has been developed to that stage of excellence where these advantages cannot be said to apply exclusively to the steam engine.

With the experimental work that is being conducted in the development of the internal combustion motor using lower cost fuels than gasoline, and with promising results, who can predict the final outcome of the motive power that will be the most satisfactory from all points of view for the rail motor car? It is probable that both types will have their distinctive fields, depending upon the availability of the fuel.

A Form to Give the History of Locomotive Movements at Terminals.

Committee—G. M. Basford, chairman; H. M. Carson, C. E. Chambers, T. Rumney, J. E. Muhlfeld.

Co-operation between the mechanical and operating departments is always necessary, but it becomes vital during periods of congestion or when, for any reason, power is in great demand.

Your committee was instructed to propose a blank form for use at terminals, to give the history of the movement and time of every locomotive from the time of leaving a train until it takes another, the object being to secure closer co-operation between the mechanical and operating departments.

With this in view, a joint blank is submitted (see illustration), which is arranged in such a way as to necessitate co-operation in the record itself by rendering it necessary for each department to fill in the items, the control of which lies in its own hands. In this way each department may become conversant with the delays and the reasons for delays for which both departments are responsible.

It is recommended that the roundhouse and the yard shall use the same form, one for each twenty-four hours. Both the roundhouse and the yard should make its own entries in duplicate—an original and a carbon copy. Immediately at the close of the day, after midnight, the carbon copies may be exchanged and the record completed on each original copy. If sufficient force is available, the records may be combined or completed by a third party. By such a plan close co-operation may be expected, because the local head of each of these departments will, at all times, see that his own record is but part of the whole. Each of the officials will also see where his work fits into that of the other.

In the blank proposed, columns A to F, inclusive, indicate train and engine numbers, the name of the engineer and the time of arrival at the yard, the ash pit and the roundhouse.

If necessary, columns may be added to indicate whether the engine is in freight, passenger, switch or work service; but these are not recommended by your committee for use where they are not necessary.

Column G will show the time when orders for engines are received. This information may be important in checking the work of the roundhouse. Column H shows the time engines are promised, and column I when they are actually ready.

Columns J and K show the number and leaving time of trains for which engines are ordered. Columns L, M, and N show when engines leave the roundhouse, when they arrive in the yard and when they are coupled to trains.

* See American Engineer, April, 1907, page 134.
† See American Engineer, April, 1907, page 134.

THE A, B AND C RAILROAD

DAILY RECORD OF LOCOMOTIVE MOVEMENTS AT ______ ______TERMINAL

______________DIVISION,

FOR 24 HOURS, ENDING MIDNIGHT,______________190

Arriving						To be Ready			Departing								Mechanical Delay		Transportation Delay	
									Ordered For					Departed						
Train No	Engine No	Engineer	Time in Yard	Time on Ash Pit	Time at Round house	Time Order Rec'd	Promised	Ready	Train No	Time	Left Round-house	Arrived in Yard	Coupled to Train	Train No	Time	Engineer	R M	Cause	R M	Cause
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q				
Average																				

Columns O, P and Q indicate the number and time of the departing train; also the name of the engineer.

In the remaining columns the delays, both mechanical and transportation, are indicated together with the reasons therefor.

On roads where clerical force is not available it may be desirable to have enginemen supply information for columns A, B, C, D, E, F, L, M and N. For this purpose a small blank form is presented—merely as a suggestion—as a part of this report (see illustration). One form may be used for arrival as well as

ENGINEMAN'S DAILY REPORT

FOR 24 HOURS, ENDING MIDNIGHT, ______190

DIRECTION (East or West)

			Time Arriving			Time Departing		
Train No	Engine No	Engineer	In Yard	On Ash Pit	In Round house	Leaving Round-house	Arrived in Yard	Coupled to Train
R	S	T	U	V	W	X	Y	Z

departure. For the arrival record the engineer should fill out columns R, S, T, U, V and W. For departure he should fill out columns R, S, T, X, Y and Z. Upon arriving at the ash pit on an incoming engine he should send the blank to the roundhouse, and upon coupling to an outgoing train he should leave another blank with the yardmaster. This information may then be easily transferred to either the roundhouse or the yard record, depending upon whether the engine is arriving or departing.

Your committee submits the record form with the recommendation that it be tried experimentally for a year by as many railroads as possible, with a view of gaining opinions from experience upon which to base further action of the Association upon this subject. We also suggest the advisability of securing the opinions of leading operating officials concerning such a blank form, whether or not these officials have an opportunity to put it into service.

It is also suggested that during periods of congestion an energetic man be placed at each locomotive terminal to follow up locomotive delays by aid of this form.

The blank form recommended herein should be understood as offering means for accelerating movements of locomotives when locomotives are greatly needed. Unless acceleration is especially desired, it seems inadvisable to stimulate action on the part of roundhouse forces to hurry the handling, inspection and, more especially, the repair work when there is ample opportunity to take sufficient time to improve the quality of maintenance and inspection and at the same time economize in the cost by eliminating overtime and other irregular work for which a premium must be paid. Your committee does not desire to recommend the continuous use of this blank form, except in cases where it may be necessary to increase the activity of terminal operations. Its occasional use to check locomotive service may, however, be exceedingly valuable.

The tendency toward placing an unnecessary burden by exacting unnecessary conditions from either the transportation or the locomotive department should be discouraged. One purpose of this blank form is to enable each department to help the other. It should not be the desire of either the motive power or the transportation department to show the other department that its own work is done and lies waiting. While such a case frequently brings about the desired result, it is an expensive matter for either department to carry on its work in such a way for the purpose of unnecessarily stimulating action on the part of another department.

In conclusion, your committee would point out the importance of introducing this form in service with a complete understanding on the part of all concerned that the necessary requirement is to reduce delays; that the purpose is to secure smooth, quick service; and that the blank is in no way intended as a means for placing responsibility upon another department. If each department will use it to improve its own performance, the desired result will be attained.

Tire Shrinkage and Design of Wheel Centers.

Committee—F. J. Cole, chairman; J. E. Muhlfeld, W. A. Nettleton, D. J. Durrell, W. L. Tracy.

Your committee made a report of Shrinkage Allowance for Tires in 1905 to this Association. The suggestions of the committee at that time were as follows:

Shrinkage 1-80th of an inch per foot in diameter for cast-iron and cast-steel centers less than 66 inches in diameter.

Shrinkage 1-60th of an inch per foot in diameter for centers 66 inches and over in diameter.

Minimum thickness of tires should be established, due consideration being given to the diameter, service and weight per wheel.

Tire and wheel gauges should be of good design, heavy enough to resist bending and subject to frequent inspection to insure accuracy.

Seventy-two inches diameter of wheel center should be included in standard sizes.

Wheel center rims should preferably be uncut, but, if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal to be used.

In the discussion which followed the reading of the paper the design of the cast-steel wheel centers was considered and a motion was made by Mr. Deems to refer the subject back to the same committee, and ask them to take into account the design of wheel centers and to consider principally the question of parted or solid rim, and whether retaining rings or shoulders on the tires should be used.

At the meeting in 1906 your committee submitted a report as requested, but unfortunately none of the members were present at the meeting, so that no definite conclusion was reached, nor was any one present to answer the questions which were raised in the discussion which followed the reading of the paper. In that report* definite recommendations were made and illustrated by sketches for the section of spokes and rim. The different forms of retaining rings most generally used were also illustrated and described. Answering the questions raised during the discussion: Mr. Brown criticizes the use of the lip on the outside of tire. This is used by the Pennsylvania Railroad in connection with their retaining segments, by the Canadian Pacific and other roads, and is quite largely used by builders for locomotives for export. The object is to prevent the wheel centers from being pushed through the tire in case it becomes loose. By inserting shims from the inside, as stated by Mr. Vaughan, no particular difficulty need be anticipated, and when it is remembered that the frames and other obstructions on the inside cover only a portion of the surface of the wheel, so that below and above the frames it is possible to insert the shims from the inside with but little inconvenience.

Mr. Fowler considered the differences in the hardness of tires and its effect upon the rolling-out action. The usual practice in rolling tires is to use a softer material for passenger tires, medium for freight and very hard for switching. The tensile strength and elongation given in Bulletin No. 14, American Society Testing Materials, is as follows:

Service.	Passenger. Lbs.	Driving. Freight. Lbs.	Switching. Lbs.	Truck and Trailing. Lbs.
Tensile strength per square inch not less than	100,000	110,000	120,000	110,000
	Per cent.	Per cent.	Per cent.	Per cent.
Elongation in two inches not less than	12	10	8	10

Regarding the use of retaining rings, your committee did not feel justified in recommending any particular form, on account of the great diversity of practice in their use.

Referring to the additional subject we have been asked to consider, namely, "Distortion of Wheel Centers and Tires Out of Round Due to Heavy Counterbalance," we are of the opinion that this whole question is so involved that it had better be made the subject of a separate committee. A great deal of work has been done in the past investigating the question of flattening of tires other than by sliding, and apart from the flattening action between the spokes which might result from a thin tire in

* American Engineer, August, 1906, page 322

combination with wheel centers having too light sections of spokes and rim, it does not seem to be a matter which need necessarily be discussed with the shrinkage of tires and design of wheel centers.

If the suggestions of your committee are generally adopted for the section of spoke and rim for cast-steel wheel centers, it will result in eliminating any possibility of distortion taking place from the above-named causes, as it will be generally found that wheels made from these suggestions will be much heavier than many designed some years ago, so that the last subject assigned could more properly be taken up and considered by a separate committee, with a view to saving time, which would allow some definite action to be taken at this year's meeting of the reports which have been submitted for the two previous years.

In conclusion, your committee would renew its recommendations made in 1905 and 1906, and the whole question, if considered advisable by the Association, may then be referred to letter ballot.

Superheating.

Committee—H. H. Vaughan (Chairman), Le Grand Parish, C. A. Seley.

There have been but few engines equipped with superheaters during the year 1906, with the exception of those constructed for the Canadian Pacific Railway. The following statement shows the engines in service December 31, 1905, and December 31, 1906, as reported by the members of this Association.

ROAD.	No superheaters. 1905.	No superheaters. 1906.	Type of engine.	Type superheaters.
L. S. & M. S.	0	1	2-6-2	Cole.
	....	1	2-6-2	Vaughan-Horsey.
C. B. & Q.	1	1	....	Cole.
	....	2	....	Schmidt smoke-tube.
Boston & Maine	0	1	4-6-0	Cole.
C. & N. W.	1	1	4-4-2	Cole.
	1	0	4-6-0	Cole.
M. St. P. & S. S. M.	2	1	....	Cole.
Rock Island System	2	2	4-4-2	Cole.
	4	4	4-6-2	Cole.
Canadian Pacific	1	1	4-6-0	Schmidt smoke-box
	1	1	4-6-0	Schmidt smoke-tube.
	1	1	4-6-0	Schmidt smoke-tube
	10	10	4-6-0	Schmidt smoke-tube
	30	55	4-6-0	Cole return-bend.
	10	45	4-6-0	Vaughan-Horsey.
	5	5	4-6-0	Vaughan-Horsey.
	1	0	4-6-0	Cole field-tube.
	1	2	4-6-0	Vaughan-Horsey.
	0	16	4-6-2	Vaughan-Horsey.
	20	20	2-8-0	Schmidt smoke-tube.
	21	0	2-8-0	Cole field-tube.
	0	20	2-8-0	Vaughan-Horsey.

From this table it will be seen that on the railways in the United States there were 11 engines with superheaters at the beginning of 1906 and 14 at the end of that year, 2 having been removed and 5 applied, and on the Canadian Pacific Railway there were 101 in service at the beginning and 176 at the end of the year, 22 having been removed and 97 applied. It is also of interest to state that during 1907 the Atchison, Topeka & Santa Fe and the Pittsburg, Shawmut & Northern have each received engines equipped with the "Vauclain" type of smoke-box superheater and that Purdue University locomotive Schenectady No. 2 has been equipped with a "Cole" return-bend superheater.

The Canadian Pacific also have received or on order 176 additional engines, all of which are equipped with the "Vaughan-Horsey" superheater.

Coal Economy.

Of the roads using superheaters, the Minneapolis, St. Paul & Sault Ste. Marie and Rock Island are unable to give any figures on coal consumption. The other roads report as follows:

Lake Shore & Michigan Southern.—Coal and water consumption were measured on Class J-40 engines with and without superheaters on several trips, and the average results show a saving of coal of from 19 to 27 per cent. and of water of from 11 to 24 per cent. on the superheating engines.

Chicago, Burlington & Quincy.—The fuel consumption of engines equipped with "Cole" and "Schmidt" smoke-tube superheaters as compared with other engines of the same class, covering the months of October, November and December, is shown in the table below, the figures being pounds of coal consumed per 100 ton-miles:

	Oct. lbs.	Nov. lbs.	Dec. lbs.
Cole superheater engine 1989	17	15	17
Average consumption of 9 engines of same class	16	16	—
Average consumption of 11 engines of same class	—	—	18
Schmidt superheater engines 2098 and 2099:			
Engine 2098	19	21	23
Engine 2099	18	17	23
Average consumption of 18 engines of same class	19	—	—
Average consumption of 17 engines of same class	—	22	—
Average consumption of 27 engines of same class	—	—	22

Boston & Maine.—Comparative tests in heavy fast passenger engine service over hard division between one engine with "Cole" return-bend type and another of the same class but without superheater gave the following results:

	Superheated.	Saturated.	Per cent. Gain.
Ton-miles per 1,000 gallons of water	6366	5667	12.3
Ton-miles per pound of coal	5.16	4.5	14.7

The average superheat was 98.6°.

Chicago & North-Western.—Comparative tests made between identical engines of the 4-4-2 and 4-6-0 type, equipped with the "Cole" superheater and not so equipped, only such tests as were reliable being included, showed that the pounds of water per H.-P. hour were 7 per cent. less and the pounds of coal per H.-P. hour 9.2 per cent. less with the superheater than without it.

Purdue University.—Prof. W. F. M. Goss reports as follows: 'The experimental locomotive of Purdue University, which for several years has been operated as a simple engine using saturated steam, was last summer equipped with a 'Cole' superheater. In preparing the superheater it was desired that the extent of superheating surface should be made as large as practicable in order that experiments with the engine might involve as high rates of superheating as practicable, and to this end a larger sacrifice of direct heating surface was perhaps permitted than would ordinarily be the case.

"At this date the experimental locomotive has been operated 3,300 miles since equipped with the superheater. Under normal conditions of running with a wide-open throttle the steam delivered at the header is superheated from 120° to 190° F., the precise amount depending upon the rate of power at which the boiler is operated. It is least when the rate of power is lowest and greatest when the rate of power is highest. Between the header and valve box there is a loss of 30° superheat, due, of course, to the cooling effect of the cylinder.

"While the data for the tests in question have not been entirely worked up, enough has been done to show that the consumption of superheated steam per horse-power hour varies from less than 20 to about 22 as maximum, this performance being under a wide-open throttle and at such speeds and cut-offs as are practicable. These values are to be compared with those obtained when the cylinders are supplied with saturated steam, which will range from 24 to 27 pounds.

"There has been no trouble arising through leaks either in superheater or in the large flues which accommodate the pipes."

The figures thus given for steam consumption with the superheaters are 83½ per cent. and 81½ per cent. respectively of the consumption of saturated steam.

Canadian Pacific.—On account of the large number of superheater engines on this road and the close attention paid to fuel consumption a quantity of records are available of the results in road service, but they are not in many cases available for comparative purposes on account of the small number of modern simple engines in use. Previous to the introduction of the superheater, compounds had for some years been constructed for freight service and a comparison of the superheater with the compound is not entirely satisfactory, since it assumes that the compound is more economical than the ordinary simple engine, which may not always be the case. During the past year, however, the "Cole" field-tube superheaters were removed from the twenty-one engines of the M-4b class and they proved a very satisfactory and economical simple engine, and they can in many cases be used as a basis for comparison. (For the purposes of record a number of tables were given, showing the comparison of the superheater engines with the M-4b simples, the D-9 compounds and the M-1-2 and M-3 compounds.)

In general the above tables show satisfactory results for the superheater, but it is difficult to estimate from them any exact figures of the saving obtained.

In place of relying on records taken over a period of several months, a method of comparison may be employed which, while laborious, is accurate if carefully compiled, namely, by comparing month by month and section by section the amount of coal actually burned by any class of engine with that which it would have burned had it used the same amount per unit of work as the class against which its efficiency is to be measured. For example: in August, between White River and Schreiber the M-4a engines used 249 tons of coal at 127 pounds per 1,000 ton-miles while the M-4b used 263 tons at 130 pounds. Taking the M-4b as a basis, had the M-4a consumed the same amount

per 1,000 ton-miles they would have burned 272 tons in place of 249. By considering only those cases in which the class taken as a basis did sufficient work on any section in a month to render the comparison reliable, a series of results are obtained, which, when summed up give, over any required period and for any number of sections, the actual coal burned and the equivalent coal which would have been burned by any class of engine had its consummation been equal to that of the class with which it is being compared during each month on each section, subject only to the assumption that the unit conditions, as they may be termed, will equal. An advantage of this method is evidently that one favorable record has but little effect on the total result, and as each individual result is compared under similar conditions the sum total represents, with probably the greatest degree of accuracy that can be obtained from road records, the general result over a considerable period of time.

This method has been applied to the coal records on the Canadian Pacific where comparisons are possible, with the following results:*

Class of engine taken as basis, M-4b, freight service:

Section or division.	Class.	Coal used.	Equivalent coal.	Relative consumption.
Lake Superior	M-4a	8,474	9,414	90.0%
	D-10b	7,683	8,328	91.6%
	D-10c	... .	... .	90.6%
Newport-Montreat	D-10c	2,835	3,305	85.8%
	M-1-3	2,966	3,293	90.0%
	M-4e	220	342	64-2%
Megantic-Farnham	M-1-3	1,038	1,188	87.4%
	D-10c	2,548	2,920	87-3%
Field-Revelstoke	M-4e	7,536	8,830	85.3%

Class of engine taken as basis, E-5, passenger service:

Chalk River-North Bay	E-5de	1,617	2,015	80.2%
	G-1-2	915	1,012	90.4%
North Bay-Cartier	G-1 2	4,465	5,701	78.3%
Other Lake Superior	G-1-2	1,196	1,249	95.8%

Class of engine taken as basis, D-10c, freight service:

Eastern Division	D-10b	6,266	5,636	111.4%
Ontario Division	D-10b	6,315	5,816	108.6%

In these figures, neglecting M-4e between Newport and Montreal, where the amount of coal burned is insufficient to form a reliable opinion, there is evidently a saving in coal of from ten to fifteen per cent. in the case of freight engines. It should be noted that on the Lake Superior Division the M-4 class, other things being equal, should show a result about five per cent. better than the D-10, as on this division a consolidation engine, on account of the short one per cent. grades, is more economical than a 10-wheeler. This accounts for the D-10 engines which obtain a rather higher superheat than the M-4a showing only the same saving as compared with the M-4b. From Newport to Outremont the 10-wheel type is slightly the more economical, as there is a long grade on which the reduced capacity of this type results in an improved coal performance 14.2 per cent. and probably an average saving of 12 per cent. would perhaps be about correct. From Field to Revelstoke the service is very heavy, and the engine M-4e here compared to M-4b are the later type superheaters with 175 pounds pressure, and the resulting saving of 14.7 per cent. is very satisfactory.

An interesting result is the saving of 19.8 per cent. made by the E-5d as compared with the E-5. The E-5a engines are converted 10-wheel passenger engines of the E-5 class and are identical except as regards the superheater, and these results, together with the general experience on the Canadian Pacific, show that the saving in passenger service is greater than in freight.

The G-1-2 results are not of much value, as the Pacific type engine is of far greater capacity than the E-5, but on certain runs where the work done has not been much increased they have shown a very large saving.

The D-10b show a result substantially equal to the D-10c on the Lake Superior Division, but considerably poorer on the Ontario and Eastern Division, which is partly due to the leakage at the headers which developed in the latter case to a large extent, and is intended to show its action, which accounts for the poor results obtained on other roads when the same troubles have been experienced.

The records on the Canadian Pacific are fairly well in accordance with the tests on some of the other roads reporting and with those on the testing plant at Purdue. One fact is worth noting, that there is apparently a greater saving of coal than of water, the opposite of what might have been expected This may be explained by the decrease in the efficiency of the locomotive boiler as the rate of evaporation increases, so that a saving of 10 per cent. in steam consumption decreases the rate of combustion to an extent which renders the boiler more efficient, and results in a still greater saving in the coal consumption. It might be objected that some of the reports show but little saving, and the experience on the Canadian Pacific would confirm this, as they are accompanied by complaints of the leakage occurring at the header, and in that case whatever saving was effected by superheating would be lost by the engine not steaming freely. In general it would appear that superheating may be stated to show a saving of 10 per cent. to 15 per cent. of coal in freight service and 15 per cent. to 20 per cent. in passenger service, a result that must be considered satisfactory if not quite as revolutionary as the earlier reports would have indicated.

Some tests that are of interest have been made on the Canadian Pacific showing the amount of superheat obtained, and are shown in Figs. 1 to 8 attached (not reproduced). Figs. 1 and 2 show respectively the results obtained in the M-4a with "Schmidt" smoke tube and M-4b with "Cole" Field tube superheaters. The former gives an average temperature of about 460°, while the latter showed but little superheat, and on account of the difficulty in keeping the tubes clean and the small advantage obtained the apparatus has been removed and the engines used as simples. In these tests the temperature was taken in the branch pipe, but in those following it has been taken at the steam chest. Figs. 3 and 4 show two tests in class E-5d and show a temperature of 540° and 560°. These engines have twenty-two 5-inch tubes in a 64-inch shell, the largest proportion of superheating surface so far tried, and have, as above mentioned, proved exceedingly economical and are reported to have a capacity of 5 per cent. to 10 per cent. greater than corresponding simple engines. Figs. 5 and 6 show tests of the D-10b and Figs. 7 and 8 of the D-10c engines, both having twenty-two 5-inch tubes, the former with "Cole" and the latter with the "Vaughan-Horsey" superheater, the arrangement, with the exception of the headers, being practically identical. The former show temperatures of 460° to 470°, the latter 500° to 510°, the difference being due either to the more completely separated headers, or to the more even flow of steam.

Experiments have also been made to determine the loss in pressure through the superheater, and in an engine having twenty-two tubes each containing two return bend elements, and either of the M-4 or D-10 classes, it is found to be about 5 pounds under general working conditions.

MAINTENANCE.

All roads reporting, with the exception of the Lake Shore & Michigan Southern, have experienced considerable difficulty with the joints between the main and sub-headers on the "Cole" superheaters leaking, and this unfortunate defect has been a very important factor in the lack of interest shown in superheaters generally. On the Canadian Pacific, where a large number have been in service, the delay to power and failures through engines not steaming has been most serious, the more so since at first no trouble developed. It is probably due to the shock in starting and switching causing the weight of the superheater pipes to work the sub-headers backward and forward and thus start the joints, and when once started the escaping steam cuts both the gasket and the seats away rapidly, and when once the latter are injured, remaking the joints is a tedious and difficult matter. It is also a peculiarity of the "Cole" superheater that it can leak very badly at the header joint and yet not affect the steaming qualities of the engine sufficiently to prevent its taking a train, and while this is an advantage in one respect it means, in busy times, that the joints are liable to get into a rather bad condition before they are attended to. Attempts are now being made to overcome this difficulty by securing a heavy angle-iron across the smoke-box at the bottom of the headers, and fastening them to it so as to prevent their movement, also by increasing the bolting at the joints, and it is believed that this will remedy it.

The "Schmidt" superheater has, on the Canadian Pacific, given, in the majority of cases, exceedingly good results and has run from shopping to shopping without attention. When for any reason the joints start it is very difficult indeed to get them tight without going over the face of the header and facing up the flange joints anew, and this work is slow and means considerable delay in a roundhouse. Should any leakage occur at a return bend there is also considerable work to make repairs if the leak occurs in the top or second row of pipes, on account of

* For further dimensions of these locomotives see AMERICAN ENGINEER AND RAILROAD JOURNAL, May, 1906, pp. 161.

having to take down the bottom row to get at the others and having to make the joints over again in putting it up.

It takes two or three days to make the entire set of joints when the faces are in good condition, but this time may, of course, be increased if the joints have been leaking and the faces are cut, and the job is then a serious one.

The "Vaughan-Horsey" superheater gave considerable trouble at first, on account of the fittings and nuts being made of bronze, which softened under the high temperature in front of the superheater tubes and frequently gave out. During the past nine months these fittings and nuts have been made from steel forgings and this difficulty has been overcome. Some of the upset ends of the superheater pipes also broke off, but it was found that this was caused by the method of manufacture and they are now made in two operations with satisfactory results. Some pipes have pulled out of the return bends, caused by sufficient attention not being paid to their length being correct, and they are now made as closely alike as the threads permit, namely, within ¼ inch, and the longer pipe is attached to the upper header so as to equalize the difference in expansion. The only difficulty now being experienced is an occasional loosening of the nuts, and while this is not serious it is annoying, and has led to an occasional engine failure. A simple form of lock-nut is now being used which will prevent this, and it is hoped that this type of superheater will not add to an appreciable extent to the ordinary troubles of a locomotive.

There have been a number of cases of leakage at the return bends caused by a peculiar deterioration of the small pipes. This

trouble with stopping up with the Field tubes, there has been no trouble except on the Chicago, Burlington & Quincy, so that it would appear that, with the majority of the coals in use, this difficulty is not serious.

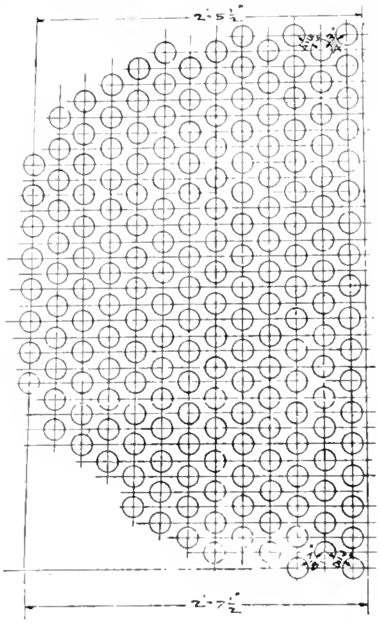
Cost of Repairs.

The Chicago, Burlington & Quincy.—The experience with superheaters on this road was very unfortunate. The header on the locomotive with the "Cole" superheater could not be kept tight, and trouble was experienced with the "Schmidt" superheater, both with the joints between crotch pipe and the dry pipe and with the gasket joints on the superheater pipe flanges. They have also had several pipes break at the return bends and all round have had an excessive amount of trouble that would indicate the superheaters were not applied with sufficient care in the first place.

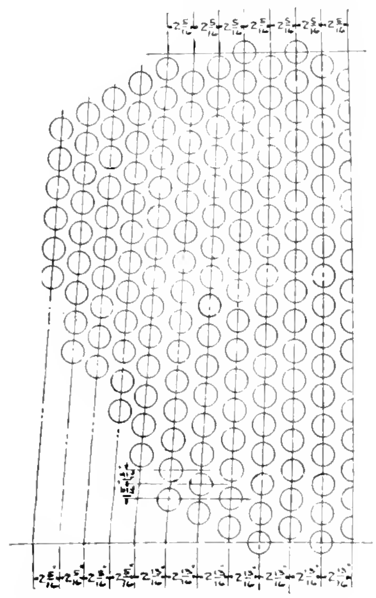
Canadian Pacific.—The cost of repairs to superheater engines on the Canadian Pacific has not shown any serious increase over simples.

Lubrication.

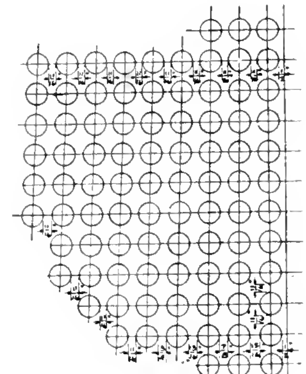
The idea that forced feed lubrication was necessary with superheated steam proved to be entirely wrong. It is true that insufficient oil produces bad results more quickly with superheated than with saturated steam, but the sight-feed lubricator is equally as satisfactory with the former as with the latter and, in fact, rather better on account of the drop in pressure on account of the steam being wire-drawn in passing through the superheater. Satisfactory results are obtained with one feed



Vandalia R. R.
Sketch No. 1.



The Minneapolis & St. Louis R. R. Co.
Sketch No. 2.



Central R. R. of New Jersey.
Sketch No. 3.

is due to the dampers not being properly maintained and allowing the tube ends to become overheated. After this is continued for several months the metal in the tube loses all its strength and can be broken by hand. The obvious remedy is, of course, the proper maintenance of the dampers, and this will require a better designed arrangement than has been employed in the past. There is not much difficulty in overcoming these troubles, but it may be stated that dampers must be operative or there will be trouble with the superheater pipes. In the "Vaughan-Horsey" design this is not very serious, as a leaky or defective pipe can be pulled out in a couple of hours, the joints blanked and the pipe put back when repaired at next washout, but with the "Cole" and "Schmidt" design it means taking down one or several sets of pipes with the chances of disturbing the joints on the remaining sets and very possibly a good deal of work to get everything tight again. In this connection it may be mentioned that possibly the present practice of making these pipes of solid drawn steel tubing is wrong. Iron tubing would be less affected by the heat than the steel and this material is to be tried in place of it. The large five-inch tubes have given very little trouble; in fact, in bad water districts in the West, they have been allowed to run through two sets of two-inch tubes with satisfactory results. There have been a few cases of their breaking at the threads, which has raised the question as to whether it is actually necessary to screw them into the back tube sheet, but this has not yet been decided.

The stopping up of the tubes seems to have been a peculiarity of the Field tube design. Probably the extreme end of this tube, which was not thoroughly cooled by the steam, became overheated and allowed a deposit to form on it. With the return bend type, even when using the same class of fuel that gave

to the valve chest branching into the bushing at each end of the valve, although on the Canadian Pacific one feed is used to each end of each valve. A separate feed to the cylinder is necessary, at any rate, with the quality of oil at present employed, and experiments are necessary with other grades of oil before stating what will finally be required. With good lubrication at present there is a rather faster wear of piston and valve packing rings with superheated than with saturated steam, but the difference is not serious.

Proper Spacing of Flues in High-Pressure Boilers.

Committee—C. E. Fuller, Chairman; H. J. Small, F. J. Cole, John Tonge, O. H. Reynolds.

Thirty-two members answered the questions in the circular sent out by the committee. The answers to three of these questions were as follows:

What size bridge do you recommend for good-water district? About 53 per cent. recommend bridges ¾ inch wide. Two members recommend arrangement as per sketches 1 and 2.

What size bridge do you recommend for bad-water district? Sixty-two per cent. recommend bridges from ⅞ inch to 1 inch wide. Three members recommend arrangement as per sketches 1, 2 and 3.

What arrangement of flues do you recommend? Over fifty per cent. recommend the common arrangement of flues. Three recommend special arrangement, sketches 1, 2 and 3. Two think the arrangement of flues is immaterial.

One of the members recommends very strongly a special arrangement, as shown on sketch No. 2, an arrangement which they have used successfully for a number of years, but no spe-

cial tests have been made to determine the efficiency as compared with boilers having the common arrangement of flues, although they are positive it is a great improvement over it. To determine the proper spacing of flues, this subject must be considered from the transportation as well as the mechanical standpoint; that is, the engine failures on account of leaky flues, as well as the cost of maintenance and steaming qualities of an engine, must be considered. The committee is of a uniform opinion that wider bridges, from ⅞ inch to 1 inch, or even wider, should be recommended, but before determining exactly what size bridges should be used they consider it advisable that a series of tests be made to determine the water circulation between flues, the coal consumption for boilers with different size bridges, as well as the cost of maintenance in regard to flues.

Blanks for Reporting Work on Engines Undergoing Repairs.

Committee—Theo. H. Curtis (Chairman); E. W. Pratt, C. H. Quereau, F. W. Lane.

Your committee appointed to recommend "Blanks for Reporting Work on Engines Undergoing Repairs" presumes that it was intended that this report should embrace blanks for reporting engines which are in service but need shopping, and blanks for reporting work done on engines which have undergone repairs, to be used as a permanent record. We have also presumed that the report is to cover shop repairs and not running repairs.

Under the present method of making heavy or extensive repairs to engines at one or two main shops, and of making only light or running repairs at the small division shops or terminals, and of running engines out of terminals in either direction in pool service, and where division master mechanics have no regular assignment of engines and, therefore, cannot be held entirely responsible for the condition of engines on their respective divisions, the most important and essential feature in connection with the cost of repairs of locomotives and the results of operation is that of obtaining a correct and accurate report of the condition of engines in service, that they may be sent to the shops best equipped to do the class of repairs which they need, and that the condition of the engines on the various divisions may be kept consistent with the service required.

In order to assign engines to the shops intelligently, an accurate report of their condition and a comprehensive classification of the repairs required is necessary. Your committee does not believe that the classification of locomotive repairs recommended by the committee which reported at the last convention, is best adapted for this purpose.

The operating officials in all departments are gradually adopting the use of the classification in vogue in the motive power

A. B. and C. RAILROAD COMPANY.

Mr ________________

Supt. of Motive Power ________________Division, ________190

Engine No.____________requires the following repairs and should be shopped during the next thirty days. Estimated class of repairs needed________________

ENGINE PARTS	WORK REQUIRED
Boiler . . .	
Fire Box . . .	
Flues	
Frames . . .	
Wheel Centers . .	
Axles, Driving .	
Cylinders . . .	
Crank Pins . .	
Driving Boxes .	
Tires	

REMARKS.—(State other heavy work required not shown above.)

*LAST SHOPPED.—Date____________190 Place______________Class repairs

Mileage made since last shopping ______________miles.

SHOPPING APPROVED:

Supt. of Motive Power Master Mechanic

Ordered to______________Shops, Date ______________190

Supt. of Motive Power

*Information regarding "last shopped" and mileage made will be inserted in Supt. of Motive Power's Office.

NOTE—Original of this report will be sent to the Master Mechanic of the Shop to which the engine is assigned when the assignment is made. Duplicate report will be filed in Supt. of Motive Power's Office.

Exhibit "A."

FORM 928.—Revised 2, '05

A. B. and C. RAILROAD COMPANY

OFFICE OF MASTER MECHANIC.

REPORT OF ENGINES REPAIRED AND UNDERGOING AND WAITING REPAIRS.

______________Shops, week ending______________190

ENGINES TURNED OUT OF SHOPS

Engine No	Date Taken in	Date Turned out	Class of Repairs	REMARKS

ENGINES IN SHOPS

Engine No.	Date Taken in	Date will Probably be Turned out	Class of Repairs	If delayed Waiting Material, State Briefly what it is and Date and Number of Requisition on which Ordered.

Engines Out of Service, Waiting Repairs Account of No Room in Shops

Engine No	Date Taken out of Service	Class of Repairs	REMARKS

If there are facilities and space in shop available for repairs to Engines, state how many Engines could be accommodated if they could be spared from service.

MASTER MECHANIC

CLASSIFICATION OF LOCOMOTIVE REPAIRS.

$ 100.—Cost of Repairs—Class 1
300.— " " " — " 3
700.— " " " — " 7
1,000.— " " " — " 10
1,500.— " " " — " 15

Exhibit "B."

department on their respective roads, particularly with regard to engines in shop for repairs, and the classification should, therefore, be one that is free from complication and easily understood. In addition to the classification recommended by the committee at the last convention being complicated, it costs considerable more to make repairs in some cases than in others, though the classification is the same. We believe the most practical and comprehensive classification is the unit classification, based on the estimated cost of repairs, and have, therefore, used it in connection with the blanks recommended in this report. Under the unit system engines requiring repairs estimated to cost $100 are termed class "1" repairs; $500, class "5" repairs; $800, class "8" repairs; $1,500, class "15" repairs; $3,000, class "30" repairs, etc. We also consider a more detailed report than the mere classification number (under any system of classification) is necessary in order to intelligently assign engines to the shops for repairs.

In order not to hold engines out of service awaiting room in the main shop, it cannot be left to the discretion of division officials to forward engines to the main shop. They should be assigned to the shops by the head of the mechanical department, or one delegated by him to perform this duty. A record of the mileage made by each engine beween shoppings and the repairs made to the engines at previous shoppings, as well as accurate reports of the condition of engines and a knowledge of the service required on each division, is essential to intelligently make shop assignments and secure the longest and best possible service at reasonable cost.

Your committee obtained from the heads of the mechanical departments of the principal roads forms in use for this purpose and, after a careful analysis of the subject and the forms submitted, recommend the use of the following blanks:

1 (Exhibit A). Blank showing condition in detail of engines which will require shopping within thirty days. This report is in duplicate form and that part pertaining to the condition of the engine is made by the division master mechanic where the engine is in service and forwarded to the head of the mechanical department. The information relative to date, place and class of repairs, and mileage made since last shopping is inserted in the superintendent of motive power's office, and if the shopping

CLASS
BUILT AT
DATE OF SERVICE

A, B AND C
RECORD OF LOCOMOTIVES

Where Overhauled	In Shop Day	In Shop Mo	In Shop Year	Out of Shop Day	Out of Shop Mo	Out of Shop Year	Mileage Since Last Shopped	Labor Boiler	Labor Machinery	Cost of Material	Total Cost	Cost Due to Accident	Boiler	Fire Box	Flues

Exhibit F, Part 1.

RAILROAD COMPANY. ENGINE No.
OVERHAULED.

	Flue Sheet	Stay Bolts	Frames	Wheel Centers	Driving Axles	Cylinders	Driving Boxes	Tires	Cab	Tender	Brakes	

Exhibit F, Part 2.

is approved the engine is ordered to the shop best adapted to do the work and at such time as it can be relieved and space can be assigned it in the shop. The original report will, at that time, be sent to the master mechanic or superintendent of shop to which the engine is assigned for repairs, and the duplicate report filed in the office of the superintendent of motive power as a permanent record. The master mechanic making the report should be held equally responsible with the master mechanic making the repairs for failure to report repairs needed to essential parts, if they are not made.

2. Blank (Exhibit B) is a weekly report to be made by each master mechanic to the head of the mechanical department, showing "Engines Turned Out of Shop," with date taken in, date turned out, and class of repairs made; "Engines in Shop," with date taken in, date will probably be turned out, class of repairs, and, if waiting on material, the items, date and number of requisition upon which it is ordered; "Engines Out of Service, Waiting Repairs Account No Room In Shops," with date taken out of service, and class of repairs needed; "Available Track Room in Shop for More Engines," with number of additional engines that can be taken in shop.

From these reports a very concise statement (Exhibit C) can be compiled to be submitted to the heads of the operating department, but a printed form is not desirable for this statement as it can (on account of the varying number of engines in shop) be made on typewriter in more concise form.

A, B AND C RAILROAD COMPANY.

ENGINES TAKEN IN SHOPS WEEK ENDING APRIL 27, 1907.

Engine No.	Date Taken In.	Date Will Probably Be Turned Out.	Class of Repairs.	Engine No.	Date Taken In.	Date Will Probably Be Turned Out.	Class of Repairs.
Shops.				Shops.			
779	[illegible] 8	May 7	15	774	April 26	April 30	1
3861	[illegible] 8	May 17	18	446	Mar. 14	May 4	12
41	[illegible] 20	May 20	18	301	April 24	May 4	3
				[illegible]	April 10	May 10	12
Shops.				Shops.			
[illegible]	[illegible] 12	April 20	10	[illegible]	March 27	April 30	20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	April 10	April 30	7
[illegible]	[illegible]	[illegible]	15	[illegible]	March 20	May 2	18
[illegible]	[illegible]	[illegible]	4	[illegible]	April 22	May 4	5
[illegible]	[illegible]	[illegible] 1	[illegible]	[illegible]	April 21	May 8	7
[illegible]	[illegible] 24	[illegible] 4	12	[illegible]	April 21	May 11	7
[illegible]	[illegible]	[illegible] 4	[illegible]	[illegible]	April 4	May 15	22
[illegible]	[illegible]	[illegible] 7	17		April 6	May 15	25
[illegible]	[illegible] 1	[illegible]	[illegible]	[illegible]	April 21	May 16	13
[illegible]	[illegible]	[illegible] 11	17	[illegible]	April 19	May 18	20
[illegible]	[illegible]	[illegible] 11	23	[illegible]	April 19	May 22	20
[illegible]	[illegible]	[illegible] 11	18	[illegible]	April 26	May 25	22
		[illegible] 11		Round House.			
[illegible]	[illegible]	[illegible]	40	[illegible]	April 22	April 24	1
[illegible]	[illegible]	[illegible]	5	[illegible]	April 22	April 25	1
		[illegible]	[illegible]	[illegible]	April 21	April 26	1
				[illegible]	April [illegible]	April 29	1
				Shops.			
		[illegible]	[illegible]	[illegible]	April 24	April 26	2
		[illegible]	[illegible]	[illegible]	April 19	April 29	5
		[illegible]	[illegible]	[illegible]	April 5	May 1	8
		[illegible]	1	[illegible]	April 24	May 4	5
		[illegible]	1	[illegible]	April 24	May [illegible]	5
		[illegible]	[illegible]	1	April 5	May 20	20
				Shops.			
				[illegible]	April 26	April 29	1
				119	April 21	April 30	2
				Shops.			
[illegible]	[illegible]	[illegible] 15	[illegible]	[illegible]	April 22	May 2	6

ENGINES TURNED OUT OF SHOPS WEEK ENDING APRIL 27, 1907.

[illegible] 41 [illegible]
[illegible] 116, 11[illegible]
[illegible] 704 [illegible]
[illegible] 1115

[illegible] 542 [illegible], 2150.
[illegible] 442, 2014, 1088, 1069.
[illegible]
[illegible] 705, 712, 713.
[illegible]

Supt. Motive Power.

Exhibit C.

3 (Exhibit D).* Blank showing in detail repairs made to the various parts of engines, dates in and out of shop, mileage since last shopping, cost of repairs (with that due to collision and accident shown separately), and other general information which is of interest as a permanent record.

4 (Exhibit E).* Blank showing in detail stay-bolt test and fire-box inspection and renewal of stay-bolts. This blank is supplemental to blank Exhibit D, and is an essential record which cannot practically be incorporated in blank Exhibit D.

5 (Exhibit F). Blank showing continuous shop record, mileage, cost of repairs of each individual engine. This is a permanent record for use in the superintendent of motive power's office and the information is obtained from reports made on blanks Exhibit D, as furnished by the various division master mechanics.

All of the foregoing blanks should be made of loose leaf form, that they may be bound in suitable binders. Blanks A, D, E and F should be bound with engine numbers in consecutive order and each fiscal year in separate volumes. Blanks C and B should be bound in order of date.

Many of the railroad companies submitted numerous blanks used by them in connection with shopping and repairs to engines, but we believe that a complicated system of numerous reports is expensive and undesirable and that the foregoing blanks are sufficient to furnish a practicable and permanent record of work done on engines undergoing repairs.

MASTER CAR BUILDERS' ASSOCIATION.

Forty-first Annual Convention.

Abstracts of Committee Reports.†

Height of Brake Staff.

Committee—E. A. Miller, chairman; J. E. Keegan, F. T. Hyndman.

The committee recommends that the standard maximum height from rail to top of brake staff be 14 feet and the standard distance from center of car to center of brake staff be from 18 inches to 20 inches.

Triple Valve Tests.

Committee—A. J. Cota, chairman; F. H. Scheffer, R. K. Reading, E. W. Pratt, James Macbeth.

No new triple valves have been presented for test since the 1906 meeting. The committee has decided that it will be impracticable to conduct a series of tests which will allow them to revise the present code of triple valve tests until they have the opportunity of conducting tests on the new M. C. B. 100-car rack. The Westinghouse Air Brake Company has furnished a blue-print showing the details for a 100-car testing rack with estimate of cost. This has been referred to the executive committee.

Arch Bars.

Committee—C. A. Seley, chairman; S. N. Dow, J. J. Ewing.

The committee was instructed to consider what changes in the dimensions and shapes of the standard arch bars would be necessitated if the truck wheel base should be changed from the present standard of 5 feet 2 inches to 5 feet 6 inches in order to better accommodate inside hung brakes, the matter of the angularity of the brake hanger also to be considered.

The committee, after consideration and investigation of the practice and results on various railroads, is of the opinion that the sizes of sections used on the present standard arch bars, namely, 1½ x 4½ top, 1⅜ x 4½ bottom, and ⅝ x 4½ tie bars

* Not reproduced.
† Continued from page 283, July number.

may be used safely in trucks for 80,000 pounds capacity, cars having 5 foot 6 inch wheel base; the increase of the stress due to the greater spans is not sufficient to warrant an increase in the sections.

It is the opinion of the committee that the bends next to the columns are too closely spaced, as, with the present arrangement, there is but 13-32 inch between the edge of the holes and the beginning of the bend. The committee recommends that the spacing of the bends be increased from 18½ inches to 20-inch centers, and that the horizontal distance between bends be increased from 16¼ inches to 17½ inches.

The committee also suggests that the turned-up lip on the ends of tie bars are unnecessary, and recommends that they be eliminated, the total length of the tie bar to be the same as the arch bars, or 74 inches over all.

Regarding the double nuts shown on column bolts, the committee suggests the addition of a note to the drawing, reading as follows: "A single nut with a nut-lock or a cotter may be used instead of double nuts."

The utility of the column bolt washer has been questioned and the committee suggests that the washer or its equivalent is desirable in order to provide suitable clearance for a fillet under the column bolt head. It recommends that a note be added to the drawing, reading as follows: "Column bolt washers may be omitted if bolt holes in the top arch bars are countersunk."

The committee approves the suggestion of the committee reporting on brake beams to the convention of 1906, which reads as follows: "That brake hangers should have an angle as nearly as possible to 90 degrees from a line drawn from the center of the brake shoe to the center of the axle, when the shoes are half worn."

Stresses to Which Wheels for 100,000-pound Capacity Cars are Subjected.

Committee—J. F. Walsh, chairman; E. D. Nelson, O. C. Cromwell, G. E. Carson, W. J. Buchanan.

The committee finds the subject assigned it a rather difficult one to report upon intelligently. There are a number of features in connection with it, which, in our opinion, could best be handled by being placed in the hands of specialists, such as at the plant at Purdue University, Lafayette, Indiana, or the Pennsylvania Railroad Company at Altoona, Pennsylvania.

We must consider:

Stresses Due to Load Imposed.—As the present pattern of cast-iron wheel has the tread coned to a very much greater extent than the old type of wheel, it must, in our opinion, result in an excess of pressure on the wheel tread, resulting in a local deformation of that part of the wheel in contact with the rail; and these stresses recurring persistently, as the wheel revolves, tend to produce a fracture.

The Stresses That Wheel Flanges Are Subjected to When the Train Enters a Curve.—The extent of these stresses depends on the curvature of the track, the speed of the train, the weight of the load the car is carrying. The location of the center of gravity of the car also has its effect.

The Effects of Brake Shoe Application and the Form of Brake Shoe.

We believe all of these things could be handled to a very much better advantage by those who are especially equipped for making the necessary tests.

Tests of the M. C. B. Couplers

Committee—R. N. Durborow, chairman; G. W. Wildin, F. W. Brazier, F. H. Stark.

During the past year the standing committee on tests of M. C. B. couplers has made a thorough investigation of the breakages and failures of steel couplers with the view of obtaining some reliable data concerning the location and nature of such fractures, and to recommend such changes as will strengthen the couplers in the weakest parts, improve them, and to reduce the failures to a minimum. An examination was made of approximately 5,000 broken steel couplers and 3,000 broken steel knuckles, together with the locks or their substitutes, of the more prominent types of couplers. (The results of this inspection are shown diagrammatically in Sheets "A" to "M," inclusive, not reproduced.)

The couplers represented were not all M. C. B. standard, that is to say, only about six of the types shown on the diagrams had been tested under the M. C. B. specifications to a greater or less extent during the last two years. The latest type of couplers which have been on the market for a year or two are not shown, inasmuch as an insufficient number of these later designs were found broken to compare them with accuracy.

BREAKAGE OF 5 X 5-INCH SHANK COUPLERS.

Lug Breakage.—In the 5 x 5-inch shank couplers, the lug breakages have decreased in the later type of couplers, which can be attributed to the strengthening of the lugs in design by the manufacturers, and the increased amount of metal which was added when the contour lines were last changed. The upper lug breakage has been the most serious of the three breakages grouped under this head, which can be accounted for by the fact that most lug breakages are caused by broken knuckle pins, the lower half dropping out and the upper half remaining in the head. In three types of couplers, the breakage just back of upper lug was greater than through the upper pivot pin lug, which can readily be overcome in the design.

Face Breakage.—The face breakage is generally on the increase and is by far the greatest point of failure in the coupler, and it is evident that the strength of the face has not kept pace with the increasing forces which affect it. This in part results from the greater amount of attention the lugs and the shank have received in the design, and is further accounted for by the lack of room to strengthen the section, which is limited to some extent by the space occupied by the locking mechanism, particularly with the bar type of locks. Breakage through the face into the locking-pin hole, is by far the most prominent, which is to be expected, as this is the most limited section. The guard arm breakage has run very evenly except in isolated cases, the box and rib design showing no general difference in their failures. The fracture through the upper corner of the guard arm is negligible without exception.

Shank Failures.—The shank failures appear least on the early modern couplers, while on the later types they are on the increase. This increase is chiefly due to bent shanks, but the breakage back of the head has also shown an increase, while the breakage immediately in front of the butt is also in the ascendancy. In almost every case of couplers having bent shanks the bend is in the vertical direction. It is believed that the shank failures can be materially reduced by more attention being given the individual design of the coupler by the manufacturer.

Breakage of Side-Wall and Across Horn.—Of the two odd breakages, the one through the wall behind the knuckle has been quite large in three types, but is on the decrease in the latest types of couplers. The committee feels that there should be no breakage at this point, as there should be little strain, and the design can be changed to provide for any strength necessary without affecting any other vital part of the coupler. The breakage at the horn has been low, with one exception. As an emergency stop the horn should be designed strong enough to withstand the shocks, but with the introduction of properly designed draft gears of sufficient capacity, the trouble from horn breakage should disappear.

BREAKAGE OF 5 X 7-INCH SHANK COUPLERS.

Lug Breakage.—On 5 x 7-inch shank couplers, which are all modern, lug breakages show an even greater decrease on the later types than on the 5 x 5-inch shank couplers, and with the three exceptions are below ten per cent. of the total breakages. Most of these couplers are equipped with the knuckle tail hook to prevent the knuckle from pulling out when the pivot pin breaks, which assists in preventing the lugs from breaking.

Face Breakage.—The face breakages are by far the most prominent and are considerably above fifty per cent. of the total breakages. The breakage into the face through the locking-pin hole and the breakage at the neck of the guard arm constitute the largest percentage of the failures, and these two breaks vary in the different types of couplers; in some makes the breakage through the face into the lock-pin hole is the most numerous, whereas, in the other types, the neck of the guard arm is broken more frequently. The failure of the upper corner of the guard arm has become negligible.

Shank Failures.—The shank failures in three instances are above ten per cent. of the total failures, and this is mainly due to bent shanks. The breaks immediately behind the horn and directly in front of the butt are rather constant for the different types of couplers and about uniform in the two breaks, both of which are very low, only one case reaching seven per cent. of the total failures.

Breakage of Side Wall and Across Horn.—The breakage through the side wall of the head behind the knuckle tail is excessively high in two cases, one type showing twenty-eight per cent. and the other type twenty-one per cent. of the total failures. The breakage across the horn through the locking-pin hole has almost disappeared, probably due to the more efficient draft gears applied with these couplers on the later cars, which prevent the horn from coming in contact with the end sill.

COMPARISON OF THE BREAKAGES OF THE 5 X 5-INCH AND 5 X 7-INCH SHANK COUPLERS.

In making the following comparisons, it must be remembered that they are only relative and not comparative:

Shank Failures.—The percentages of the shank breakages of the 5 x 7-inch shank couplers average less than three per cent. lower than the shank failures of the 5 x 5-inch shank couplers. Bending has been the most serious failure of the shank in the late types, and as the shank generally bends vertically, we do not obtain the full benefit from the additional 2-inch width of shank, as the additional metal is not in the right direction to stop the vertical bending most effectively.

Face Breakages.—The percentages showing the combined breakages of the face are slightly lower for the 5 x 5-inch shank

couplers, but the breakage through the face into the locking-pin hole is lower on the 5 x 7-inch shank couplers. This is accounted for by the increased width of the shank backing up the guard arm, the benefit accruing directly to the section forward of the locking-pin hole, as it will be noted that the guard arm failures in the 5 x 7-inch shank couplers are very much higher than the 5 x 5-inch shank guard arm failures. The results show, without question, that the weakest point of the couplers is in the section of the face immediately forward of the locking-pin hole. The neck of the guard arms should also receive further consideration in the way of strengthening.

BREAKAGE OF KNUCKLES.

The breakage of the solid knuckle is not confined to any particular point, but may be said to vary with the construction of the knuckle, the main failures being breakage at the pivot pin hole, the knuckle tail behind the lock bearing, breakage of the knuckle tail bearing and breakage of the coupling lug.

Breakage at Pivot Pin Hole.—The combined breakage at the pivot pin hole is divided into the breakage through the pivot pin hole and the breakage through the tail immediately behind the pivot pin hole shoulder. The breakage behind the shoulder is the more serious in some knuckles than the actual breakage through the pivot pin hole.

Knuckle Tail Behind Lock Bearing.—The breakage of the knuckle tail behind the lock bearing, or in other words, of the hook which prevents the knuckle from pulling out when the pivot pin breaks, has been pronounced, all but two of the solid knuckles represented being equipped with this safety device. The breakages show the value of the knuckle tail hook as well as the weaknesses. It will be difficult to strengthen this hook in most knuckle-throwing couplers, but it should be done wherever possible.

Breakage of Coupler Lug.—Lug breakage has diminished from the most prominent failure in slotted knuckles to one of minor importance in the solid type. A number of the fractures were the direct result of improperly designed cores, and of cores slipping when casting knuckles which have lightening cores through the lug.

DEFECTIVE METAL, POOR CORING, ETC.

The percentage of defective castings among the 5 x 5-inch shank couplers has decreased with the development, and the types which have been tested most generally under the M. C. B. specifications show the least percentages. This also holds true in the 5 x 7-inch shank couplers, where, with one exception, the tested couplers when broken have shown less defective metal than those not tested.

IMPROPER REPAIR PARTS.

In examining the broken knuckles and defective locks, your committee has found that many knuckles and locks have been purchased for repairs which were manufactured by steel foundries other than the makers of the original couplers. A large proportion of such knuckles and locks have varied from the original design to such an extent that it directly affected the operation of the coupler, which not only results in troubles from parting, but also has a direct influence on the breakage of the coupler and knuckle parts. This is aside from the question of inferior metal used in such knuckles and the fact that they are not tested under M. C. B. specifications. Separate knuckles for repairs should be purchased according to M. C. B. specifications, for economy as well as in justice to the owners of the cars who have originally applied couplers in compliance with the interchange rules and standards of the M. C. B. Association.

BROKEN LOCKS, ETC.

A large number of locks, knuckle throwers and other like parts were examined. The data obtained are of no particular value for comparison, but the examination emphasized a number of points to which your committee desires to call attention. A great majority of the lock failures were due to the breakage of the lock chain attaching the lock block to the uncoupling lever chain, which is the weak point of a lock of this type. It is not within the province of your committee to make definite recommendations concerning the form of lock, as most of the coupler patents are based on this feature, but where the flexible link connection is used from the lock block to the uncoupling lever chain it should be strengthened.

CONCLUSIONS.

This investigation has pointed out wherein the different types of couplers and knuckles are failing, and has satisfied your committee that a closer observance of the M. C. B. specifications in purchasing couplers and the insistence of the railroads on having the couplers tested in accordance with the requirements of the Association will overcome much of the trouble from breakage of couplers, knuckles and parts which is now being experienced.

UNCOUPLING ARRANGEMENT.

Defective uncoupling arrangements are an increasing source of trouble on account of the bending of the uncoupling rods, breakage of uncoupling chains and loss of pins from the clevises. The breakage of these chains is very often due to the excessive slack in the draft rigging, and as the length of chain must necessarily be limited to obtain the proper amount of lift for the locking pin it cannot well be lengthened. With the knuckle-throwing couplers the amount of lift of the locking-pin is increased, which feature aggravates this trouble. In view of the foregoing, your committee believes that some better means should be provided for operating the locking device, but is prevented from making any definite recommendations on account of patented devices. In order to provide for increased strength at this point, a recommendation is appended to make the diameter of the eyelet at the top of the locking device for uncoupling rigging, 1 1-16 inches.

The lock-set within the head of the coupler is now standard, so that there is no longer any necessity for the lip on the outside bracket, No. 1, shown in Recommended Practice, Sheet "B." The uncoupling lever is frequently allowed to hang on the lip of this casting while coupling cars, and when this is done it results in a large amount of damage to locking-pins and sometimes causes breakage of knuckles and couplers.

RECOMMENDATIONS.

The recommendations which your committee offers to be submitted to letter ballot, to be adopted either as standard or recommended practice, is as follows:

STANDARDS.

(Under this head where changes in standards also involve changes in specifications, both are included in the same recommendation.)

1. "That the lock lift must be in the central longitudinal vertical plane of the coupler, located between the striking horn and contour lines, and must operate from the top by an upward movement."

Also add this requirement to paragraph No. 4 of "Specifications for M. C. B. Automatic Coupler."

2. "That couplers must be so designed as not to part when the knuckle pin is removed or broken."

Also add to first sentence of paragraph No. 4 of "Specifications for M. C. B. Automatic Couplers,"—"and must be so designed as not to part when the knuckle pin is removed or broken."

3. Change paragraph No. 8 of "Specifications for M. C. B. Automatic Couplers" to read: "8. Every coupler and knuckle made to comply with these specifications must have a slightly raised plate or flat surface cast upon the head in plain view where it will not be subject to wear. After a lot of complete couplers have successfully passed the inspection and tests prescribed below, the letters M. C. B. must be legibly stamped upon the plate on each coupler and knuckle; this mark to be evidence that the complete coupler is an M. C. B. standard."

Add a paragraph No. 7 to "Specifications for Separate Knuckles" to read: "7. Every knuckle made to comply with these specifications must have a slightly raised plate or flat surface cast upon the head in plain view where it will not be subject to wear. After a lot of knuckles have successfully passed the inspection and tests prescribed below, the letters M. C. B. must be legibly stamped upon the plate on each knuckle; this mark to be evidence that the knuckle is an M. C. B. standard." Omit number of first paragraph under "Inspection" which is marked 7.

4. Add at the end of the first paragraph under "Jerk Test" in "Specifications for Separate Knuckles": "If preferred by manufacturers, an old coupler and lock of the same kind, in which the knuckle fits properly, and which may be suitably reinforced in order to endure as many tests as possible, may be used in place of supporting casting for this test."

5. That the "Specifications for M. C. B. Separate Knuckles" with changes as recommended above be adopted as standard.

6. "That a butt 5 x 5½ x 9⅛ inches for friction draft as shown on attached sheet 'O' be adopted as standard."

7. "That the spacing between center sills be 12⅞ inches."

8. "That front and back stops, with rivet holes, 15-16 inch in diameter spaced as shown on Sheet M. C. B. 'B', drawings 'A' and 'B,' be adopted as standard."

9. "That spacing between coupler horn and buffer beam be 1¾ inches for all spring gear and 2¾ inches for all friction gear."

10. "That followers be made of wrought iron or open-hearth steel 1⅝ inches thick for tandem spring gear and 2¼ inches for twin spring and friction gear."

11. "That the total side clearance of the coupler be not less than 2½ inches."

12. Change left-hand part of Sheet M. C. B.-11 so as to conform to sheet "O" submitted.

RECOMMENDED PRACTICE.

1. On Sheet M. C. B. "B," change dimension showing distance between gibs on all three yokes from 7¾ inches to 6¾ inches.

2. Omit uncoupling attachment casting No. 1 from M. C. B. sheet "B" and substitute casting No. 5 for casting No. 1 in diagrams Nos. 1 and 3, and omit under Recommended Practice for "Uncoupling Arrangements for M. C. B. Couplers," second sentence of fifth paragraph beginning "Diagram No. 3 shows."

3. "That the eyelet for the uncoupling attachment in the top of the locking device be 1 1-16 inches in diameter."

4. That "Specifications for Knuckle Pins" be adopted as Recommended Practice.

What Can the Master Car Builders Do to Secure More Rapid Movement of Freight Cars and Prevent Delays Under Repairs and Inspection?*

It is a well-known fact that a freight car, in addition to performing its legitimate work of transporting traffic, is required to withstand a 25-mile per hour impact when loaded and passed through gravity and hump yards; to be kicked, poled, roped and cornered; to be mauled and turned upside-down for dumping; to receive red-hot lading, such as billets, pig iron and slag; to resist the steam, fire and dynamite that is used to loosen frozen loads of coal, sand and ore; to submit to the depreciating action of acids, alkalis, water and weather; to retain any load that can be safely got into or on top of it; to endure loading by crane hoist; to undergo removal of lading by clam shell, scraper or plow; to be able to lose any part of itself that may facilitate loading or unloading, and withal to retain its identity and return to its owners after a year's sojourn in Canada, Mexico and the United States with a clear record against delay, failure, personal injury, loss or damage, and the Interstate Commerce Commission inspection. Assuming, however, that the transportation and traffic departments may have exhausted their means to increase the movement of freight by the greater lading and quicker handling of cars, there is no doubt that the Master Car Builders can render additional assistance. From the past year's experience and considering only equipment now in use, it appears that consideration should be given to the following:

(1.) Regulations to facilitate the handling at interchange points of loaded freight cars that are safe to move.

(a) If the Master Car Builders' rules are to facilitate the disposition of cars in interchange service and to properly place the responsibility for defects which may or may not make them unfit for movement, what objection should there be in stimulating car owners to make substantial repairs to equipment before it leaves the home lines by the inauguration of a rule such as:

"When a loaded car contains specified owner's defects which do not render it unsafe to move but make it liable to develop a delivering company's combination of defects, it must be accepted from owner's line if covered by a liability card authorizing repairs to, or acceptance of car on the owner's line with such a combination of defects as may properly be the result of the specified owner's defects."

Such a rule should not only facilitate the handling of loaded cars and keep them moving as long as in a safe condition, but it would also require the owners to apply the necessary betterments and repairs to equipment that they offer in interchange for the purpose of maintaining it in substantial condition and thereby relieve themselves of extraordinary expense due to cumulative repairs that are now made necessary on account of not taking "the stitch in time" when they have the cars in their possession.

(b) Another matter that should be given consideration is to make loaded and empty cars acceptable at all interchange points on such roads as will insure proper accounting for repair charges. This can be done by agreements between connecting lines providing for the appointment of joint inspectors who will prevent the holding of equipment and transferring of lading on account of too much or unintelligent inspection and on technicalities.

(c) It would also be well to establish the fact that progress is being made in interchangeability and shop practice by specifying that bad order cars shall be no exception to the rules governing serviceable cars except where they are unsafe to load on account of general worn-out condition due to age or decay. The continuance of the *per diem* on foreign cars during the period they are held for owner's material for repairs would certainly result in much less time being taken to make the repairs than what now occurs.

(2) Competent interchange and terminal car inspectors.

Taking into consideration the regular and special rules covering the inspection, condition, repairs, loading, clearances, billing and movement of freight cars, as issued by the Master Car Builders' Association, Interstate Commerce Commission and the railroad transportation and mechanical departments, it is not difficult to understand the urgent necessity for labor capable of performing the interchange and terminal inspection in a way that will accelerate rather than retard movement. Instructions and criticisms have become so frequent and voluminous that we can certainly expect a vigilant car inspector to be able to determine upon one or more details in each car passing his inspection, that will delay its movement. It, therefore, becomes most essential that the chief, foreman, joint, leading, or other similarly classified car inspector whose duty it may be to supervise regular inspectors, shall be a man of such general qualifications that he can be depended upon to direct compliance with the rules in a manner that good judgment may decide to be safe and proper for all concerned, as well as consistent with the least delay to traffic and the greatest economy in maintenance.

(3.) More substantial repairs to cars when on home lines.

* Paper presented by Mr. J. E. Muhlfeld as a topical discussion on this subject.

In consideration of the fact that the average serviceable freight car may have an earning capacity of from $2.50 to $3 per day, even when standing still for about 21 out of every 24 hours, it is easy to approximate the increased revenue that might be derived if the Master Car Builders could reduce the number of bad-order loaded and empty system and foreign revenue freight cars held over each day for all classes of accident and ordinary repairs (exclusive of defective cars held under load at destination and excepting after Sundays and legal holidays), to a basis of 3 per cent. of the total system and foreign revenue cars on the line.

However, it is an expensive procedure to clear the "cripple" tracks by the making of indifferent repairs, and where desirable system cars reach the shop tracks in an empty condition they should receive such renewals and betterments as will put them in a substantial condition, so that the repetition of the class of repair work that results only in temporary maintenance can be discontinued in order to reduce the successive line failures of equipment and detention to cars and traffic, as well as the continually increasing expenses for non-productive labor and material.

It is, therefore, especially urgent that the Master Car Builders shall promote the best interests of the shippers and dealers, as well as of the railroads they represent, by the inauguration of substantial repair practices that will insure the minimum delay of cars on the shop tracks and line of road chargeable to their general condition.

(4.) Thorough inspection, repairs and adjustment of cars before loading and careful attention to brakes, lubrication and lading after classification at load originating terminals.

Cars set off on the line of road due to bad order condition of couplers, draft attachments, wheels or brakes, heated bearings, shifted lading and other similar causes are usually the outcome of lack of proper originating terminal attention which results in accidents, destroyed lading and cars, reduced train rating, delays to traffic, blocking of passing sidings, engine and train crew overtime and extraordinary expense for sending labor and material out on the line to make repairs. Regardless of whether system, foreign or private line equipment is involved, the Master Car Builders should see that all receive the same attention in this respect, as a foreign or private line car is liable to cause just as much, if not more, line trouble when under load than a home car.

(5.) Cars damaged by accident, but safe to move, should be repaired for return loading instead of being routed home empty.

Where at all practicable to do so, light mileage on account of condition of equipment should be eliminated, and when cars can be made safe to run and lading is available they should be put in condition for return loading.

(6.) The restriction to home lines of cars that are not suitable for interchange service.

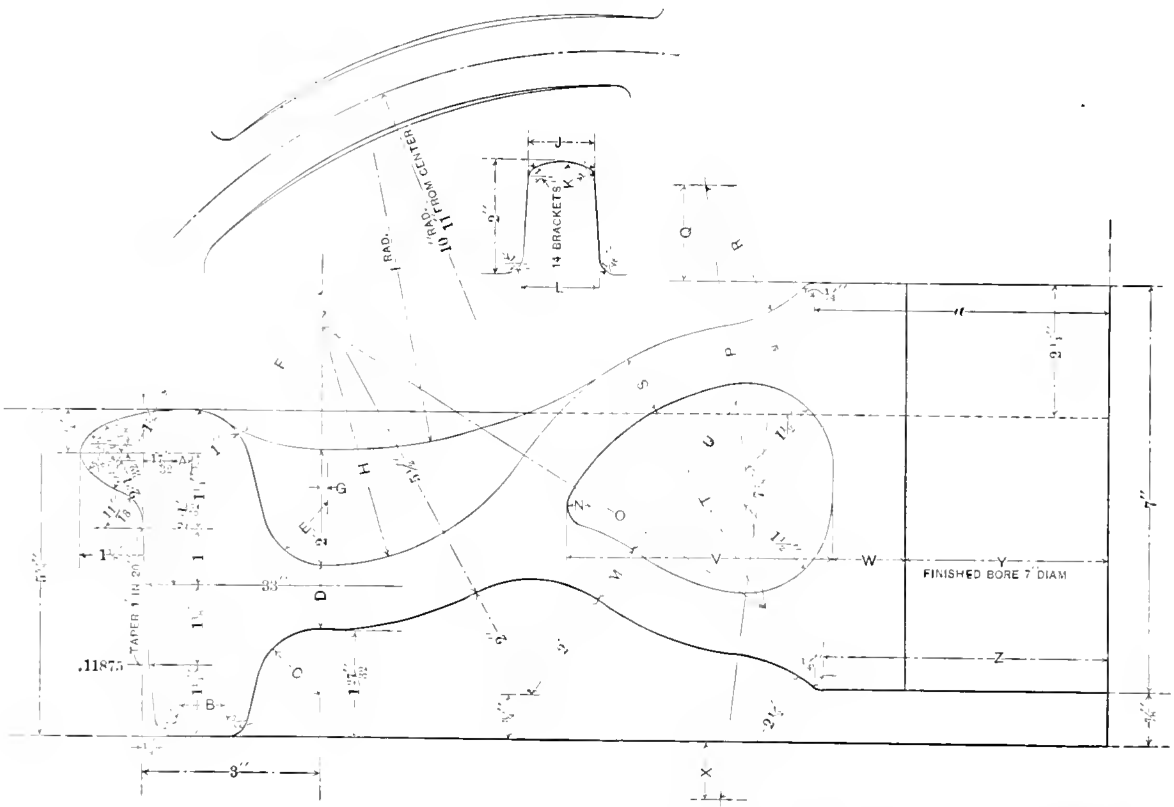
At the present day nearly all railroads are offering in interchange some loaded and empty cars that are of such capacity, design or condition as to make them entrely unfit for the service to be performed. This class of equipment, which cannot be depended upon to promptly pass interchange inspection, should be restricted to those owners' lines where it can haul the maximum amount of commercial or company's use lading with the least liability for delays, transfer or repairs.

(7.) Cars unsuitable for either company's or commercial use to be dismantled.

When a freight car of undesirable class and capacity has outlived its usefulness from the standpoint of commercial utility and reaches the home shop tracks in such bad order condition due to age, delay, corrosion or accident that the expenditure necessary to put it in serviceable condition is not justified, it should be dismantled. Connecting railroads handling either interstate or intrastate traffic should be assured of the absolute elimination of this class of equipment from further service on their lines.

In conclusion it may be stated that the great demand at the present time for increased facilities for moving industrial and agricultural products to market makes this topic of universal interest. The public insists upon railroads providing safe, fast and frequent freight service, such as can only be obtained from equipment receiving the most substantial attention in the way of repairs and inspection. The freight yard and train operations have become most severe on rolling stock. Relieving switchmen and brakemen of the necessity of going between cars to make couplings is no doubt responsible for much rough usage and failure of equipment. The gravity and hump yards and longer trains have also contributed generously to the cripple tracks. Furthermore, the conditions imposed by the placing of cars of light capacity and design between those of heavier types at the head end of trains, in combination with double, triple and overloaded equipment and the frequently reported "bad triple" and "burst hose" must also be met.

In view of the large number of cars in service that were designed and constructed long before the results from the changed conditions could be realized, the Master Car Builders deserve much credit for the progress that they have made in promulgating general practices and facilitating transportation. However,



WT. WHEEL	600 lb.	650 lb.	700 lb.
A	—	19/64	19/64
B	5/8	3/4	13/16
C	1 5/16	1 3/16	1 1/8
D	27/32	1	1 1/32
E	1 5/16	1 1/16	1 1/8
F	2 23/32	2 7/16	2 3/4
G	—	3/32	3/32
H	4 5/16	4 5/32	4 1/16
I	9 1/2	9 1/2	9 1/4
J	7/8	1 1/8	1 1/8
K	3/4	1 1/8	1 1/8
L	1 1/2	1 5/16	1 3/8
M	13/16	15/16	1 1/16
N	13/32	5/8	3/8
O	8 15/16	8 31/32	8 31/32
P	7 1/4	7 3/8	7 11/32
Q	1 1/2	1 21/32	1 21/32
R	2 1/2	2 9/16	2 7/16
S	3/4	7/8	1
T	3 7/8	3 15/16	3 29/32
U	4 9/16	4 7/16	4 5/16
V	5 7/16	4 15/16	4 9/16
W	1	1 1/8	1 1/4
X	1 1/16	1 1/32	1
Y	2 7/8	3 1/4	3 1/2
Z	4 3/16	4 11/16	4 7/8
a	4 5/16	4 13/16	5 1/16
FIN BORE	5 3/4	6 1/2	7

STANDARD 33-IN. CAST-IRON CAR WHEEL.

the urgency for the handling of freight now awaiting movement gives them an opportunity to further demonstrate their resourcefulness and broad, progressive methods by stimulating such action as will eliminate whatever sluggishness may still exist in the repair and inspection practices.

Cast-Iron Wheels.

Committee—Wm. Garstang (Chairman), A. S. Vogt, H. J. Small, W. E. Fowler, R. L. Ettinger, R. F. McKenna, J. E. Muhlfeld.

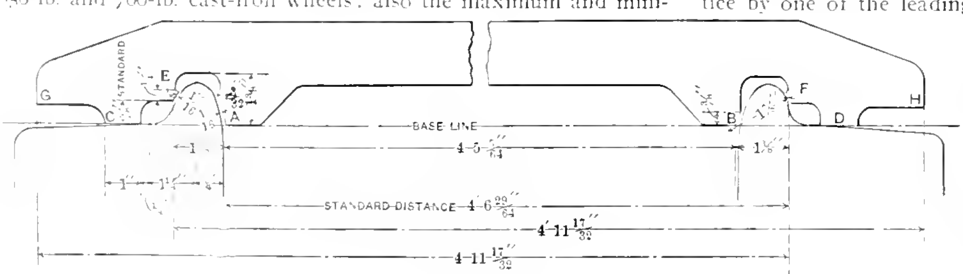
The committee reported the following outline of work accomplished during the past year, working jointly with the American Railway Association committee on standard wheel and rail sections, Mr. G. L. Peck, chairman, the personnel of the latter committee remaining the same as reported in the proceedings of this Association for 1906.

Two joint meetings of the committee were also held with a committee representing the car wheel makers of the United States, and both were of prime importance and assistance in getting the endorsement of the wheel makers, and in reviewing the commercial factors which are at present affecting the subject from the wheel makers' standpoint. The committee having received the support of Master Car Builders and American Railway Associations on its recommendations covering the *increased thickness of flange and coning of the tread* has confined its work during the past year to the revision of the drawings and specifications, and the design of a complete set of gauges of various descriptions required for cast-iron wheels, to replace those now shown in the standards and recommended practice of this Association, to suit the requirements of the new flange and tread adopted in 1906, as well as the standard flange and tread adopted by this Association and in general use prior to that date.

Revised drawings and revised portions of the specifications were presented and attention was called to certain rules and paragraphs that require revision to conform to the new standards.

The accompanying drawings show the standard 33-in., 600-lb., 650-lb. and 700-lb. cast-iron wheels: also the maximum and minimum flange thickness gauges, the standard reference gauge for mounting and inspecting wheels, the wheel check gauge and the wheel defect and worn coupler limit gauge.

The committee also presented for approval and adoption by the Association, limit gauges, as shown in the illustration, for use in shops when inspecting second-hand wheels for remounting. These gauges are designed along lines determined in actual practice by one of the leading railroads, and the angle gauging face having a taper two and one-quarter in twelve inches is the result of several years' experience, and has been found to meet requirements in a satisfactory manner.



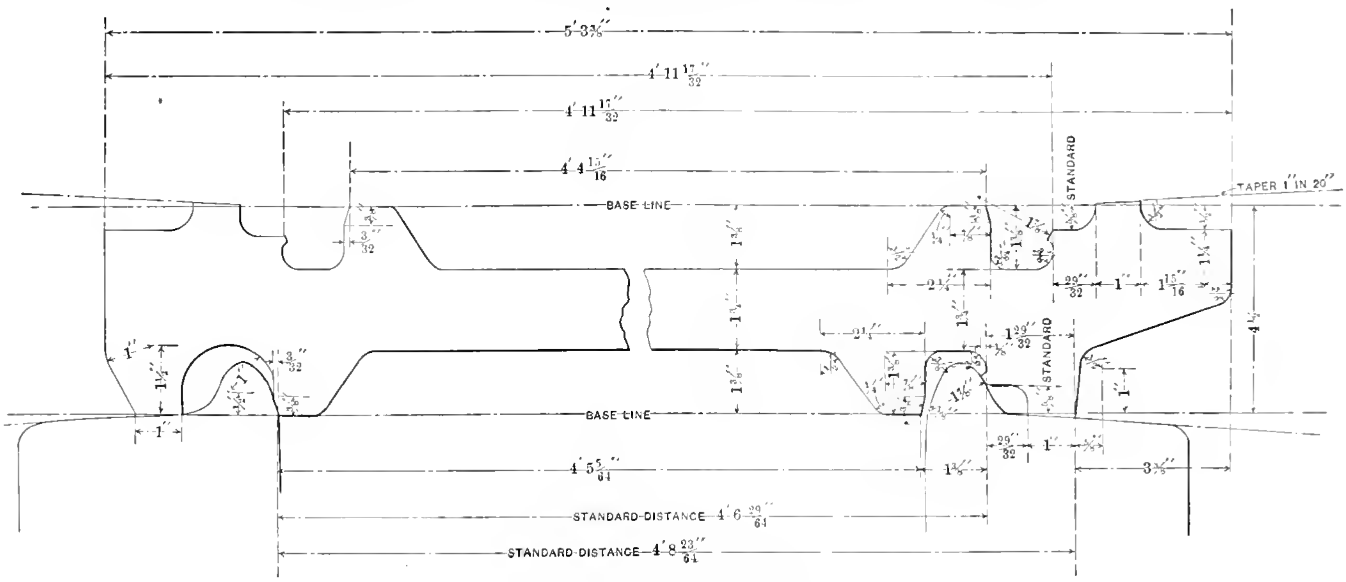
WHEEL CHECK GAUGE.

Subjects.

Committee—W. E. Symons, William Forsyth, H. LaRue.

SUBJECTS FOR COMMITTEE INVESTIGATION DURING THE YEAR 1907-1908.

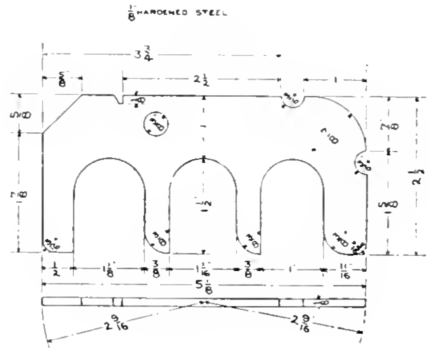
The lateral bracing of steel freight cars; also the proper design for



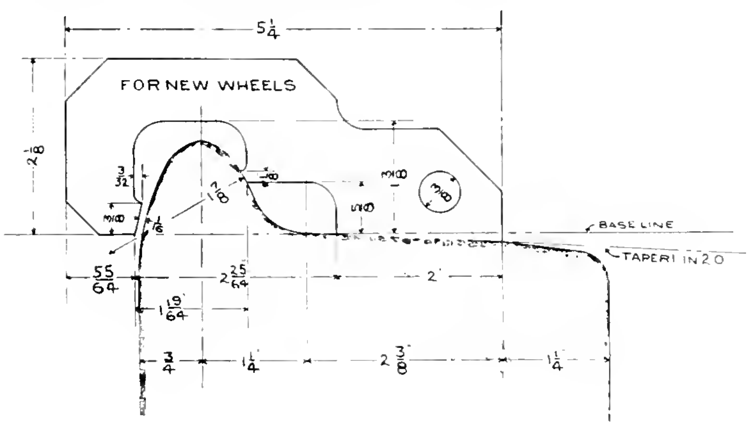
STANDARD REFERENCE GAUGE.

the superstructure of steel box cars. The majority of wooden cars have no diagonal bracing in the underframing, depending on bolted joints and connections to keep the bodies square. In the case of a severe shock a wooden car will spring and give, but return to its former lines, while cars of steel or composite construction, on account of inability to spring after a severe shock, will remain sprung and bent out of line. The same committee to investigate the design of the upper framing of box cars. C. A. Seley, W. F. Kiesel, Jr., W. J. McKeen, Jr., committee.

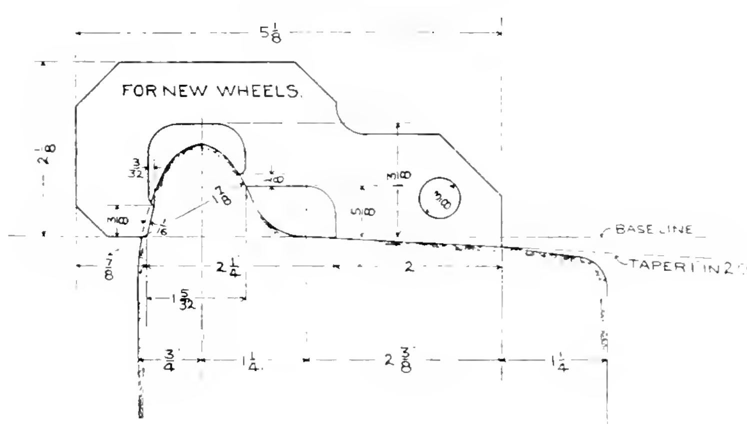
Side bearings and center plates for freight cars and locomotive tenders. Committee to recommend a standard spread, height and clearance for side bearings, review and give synopsis of reports on side bearings and center plates made to the Association in the past, since and including 1900; to present plans for the most improved anti-friction side bearings and center plates and recommend the proper proportions for ball and roller bearings. The investigation and report to embrace the relations which center plates and side bearings may bear to derailments. Alfred



WHEEL DEFECT AND WORN COUPLER LIMIT GAUGE.



MAXIMUM FLANGE THICKNESS GAUGE.



MINIMUM FLANGE THICKNESS GAUGE.

FIG. 7.

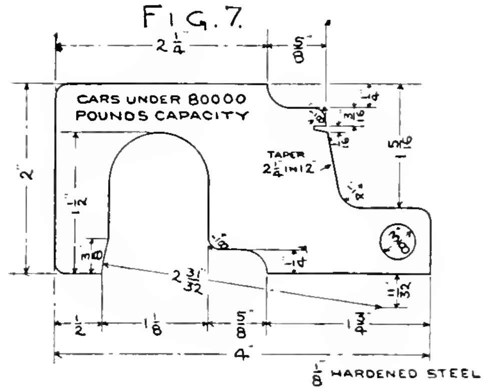
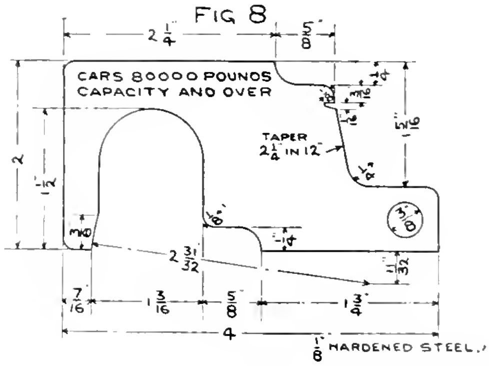


FIG 8.



[illegible] ON WHEELS.

Lovell, H. J. Small, O. M. Stimson, C. A. Schroyer, A. W. Gibbs, committee.

Friction Draft Gears:

First: To recommend a standard maximum capacity.

Second: The most desirable resistance during each ⅛-inch compression.

Third: A standard maximum weight for the friction draft gear proper.

Fourth: The proper design for the attachment of friction draft gear.

Fifth: The value of friction draft gear in reducing damage to cars and their contents. J. E. Muhlfeld, F. M. Whyte, W. H. V. Rosing, R. D. Smith, committee.

Steel Passenger Cars. To recommend a standard sectional area for the center sills and cover plates, the relative merits of steel passenger cars with an upper deck and those with a semi-elliptical section without upper deck; the best construction for flooring and relative merits of various materials for inside finish for fireproof construction. W. A. Nettleton, E. A. Benson, Representative American Car & Foundry Company, T. Rumney, R. L. Ettinger, committee.

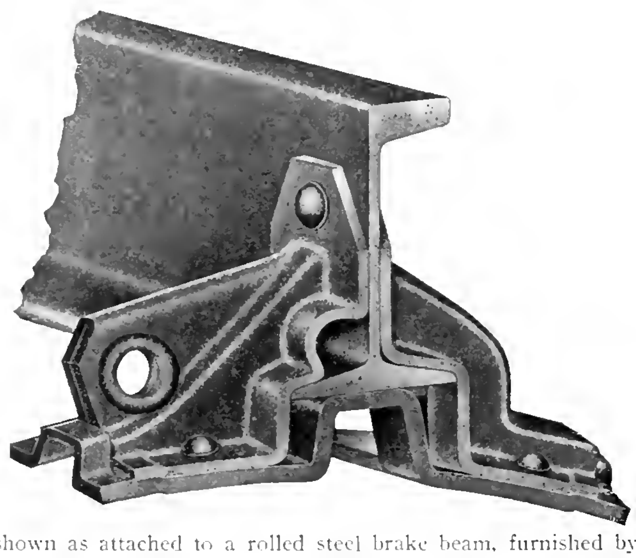
The ventilation and heating of coaches and sleeping cars. To investigate methods for the regulation of the temperature and the supply of fresh air to passenger cars with special attention to comfort in sleeping cars; to recommend plans which provide for the regulation of heat and air supply by the occupant of each berth. R. P. C. Sanderson, Joseph A. Buker, William O'Herin, W. E. Fowler, F. H. Clark, committee.

Protective coatings for steel cars; the method of application and results of experiments made therefor. C. A. Fuller, T. H. Russum, F. H. Clark, S. T. Parks, committee.

A FORGED STEEL BRAKE HEAD.

A new brake head of forged steel, which conforms in every respect to M. C. B. standards, has recently been designed and is being manufactured by the Buffalo Brake Beam Company. This head has been designed to fill the difficult requirements of modern heavy equipment and high speed, and can be considered as a distinct step in the direction of increased safety and economy.

The illustration shows the construction very clearly. The head



is shown as attached to a rolled steel brake beam, furnished by the same company, to which it is securely riveted. Riveted to the head proper is a removable face plate which can be renewed at small cost in case it should become worn by contact with the wheel through the breaking or wearing of a shoe, thus eliminating the usual necessity of scrapping the whole head. One feature tending to increased safety, which is given by a head of this design, is the fact that there are no key lugs such as are usually found on malleable iron heads, which have been known to break and permit the shoe to drop to the track, with very serious consequences. In this shoe the key has also been given a much greater bearing surface than is usually provided.

Power of Hand Brakes.—Hand brakes which will work in harmony with the air brakes should be used on all equipment, and the power exerted by the hand brake be not less than 40 per cent. of the light weight of car, nor more than that of the air brake, on passenger equipment. It is believed that the average hand brake power now available on such cars will approximate 25 per cent.—*Report of Committee, Air Brake Association.*

A REMINISCENCE OF THE CONVENTIONS.

One of the exhibits at the M. M. and M. C. B. conventions at Atlantic City which attracted much attention was that of the American Blower Company, who introduced a novelty decidedly mystifying to the wise ones. One of their high-pressure blowers was put in operation, and, emitting from the discharge a blast of air at high velocity, which held a light rubber ball about 12 in.

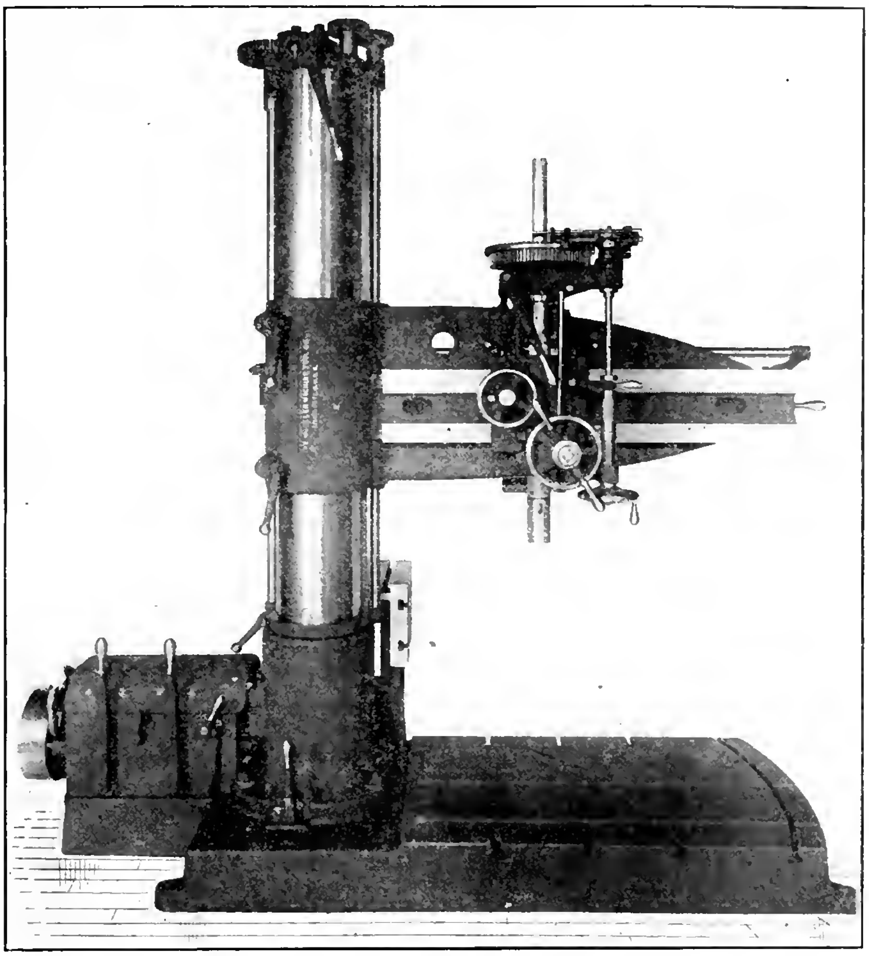
in diameter suspended about 4 ft. from the outlet. Just why the ball remained at that point instead of flying off into the ocean was what puzzled the attending engineer delegates. The invariable question propounded to the overworked representatives of the company was: "How do you do it?" Alternated with: "Where is the string?" "Some electrical control?" etc. Anyone who wants the real explanation of how it was done can obtain it by writing the American Blower Company, Detroit, Mich.

Car Efficiency.—The report of the committee of the American Railway Association on Car Efficiency shows the following conditions to have existed in this country and Canada for six different periods during this year.

Date.	Roads.	Surplus.	Shortage.
Jan. 2	74	24,517 cars	83,110 cars
Feb. 6	68	12,563 "	103,095 "
April 10	70	17,612 "	70,362 "
May 15	86	19,622 "	47,445 "
May 29	84	23,809 "	38,300 "
June 12	85	31,217 "	33,088 "

The Lighting of the Planing Mill is best accomplished by arc lamps, but these must be well enclosed to prevent the mingling of sparks and dust. It seems as if the mercury vapor lamp would be an ideal one for a mill, as there is no chance of fire from incandescent particles of carbon or by any incombustible material outside of the glass tube. If incandescent lamps are used they should always be covered with cages, as they are very liable to be struck by timbers which are being handled and turned.—*Mr. G. R. Henderson at the New England Railroad Club.*

Chemical Fire Engines for Coal Mines.—For fighting fire in its anthracite coal mines a new form of chemical fire engine is now being used by the Delaware, Lackawanna & Western Railroad. The engine is mounted on a truck suitable for the tracks throughout the mines and is hauled by means of an electric mine locomotive. Great difficulty has been experienced in putting out fires in mines by means of water on account of the formation of a gas so suffocating as to drive the fire fighters away. A chemical engine, however, works much more satisfactorily as the gases evolved are very heavy and cling to the floor and assist in smothering the fire. The fumes are not as annoying to the firemen, who can stay close enough to do effective work.



NEW FOUR-FOOT RADIAL DRILL.

A NEW RADIAL DRILL.

A new radial drill designed to meet the modern conditions of high-speed steel and maximum output is shown in the accompanying illustrations. This machine is provided with twenty-four changes of speed to the spindle and eight changes of automatic feed for each spindle speed, any of which can be instantly changed while the driving belt is in motion without noise or shock. These changes of both speed and feed are conveniently obtained and are between sufficiently wide limits to permit the developing of the full capacity of the machine under any and all circumstances.

Speed Box.—The speed box is located on the base of the machine, close to the column, and is of a very compact and convenient design. The arrangement of the gears and clutches is shown in the accompanying line drawing. It will be seen that the driving shaft carries two double friction clutches, operated from the two long levers shown in front of the speed box in the photograph, by which four changes of speed of the intermediate shaft can be obtained. The speed of the upper shaft, which carries splined to it a set of three gears which mesh with the three gears on the intermediate shaft, is controlled by the small lever shown at the right of the speed box. This has three positions, bringing either gear E, D or F into mesh with the similarly marked gears on the intermediate shaft. Thus there are twelve changes of speed obtainable by the gear box, which is increased to twenty-four by means of a back gear located on top of the column and controlled by a lever at the base. Another connection in the gear box is one which meshes gear D on the upper shaft with gear G on the driving shaft, thus causing the direction of rotation of the upper shaft to be reversed and to run at an increased speed. This connection is used for operating the elevating screw when the arm is being lowered. The lever at the base of the column controls the connection of the elevating screw.

The Column.—The column is stationary, constructed of one piece and of heavy section throughout. It is bolted to the base and there are four webs inside extending its entire length, which add materially to the strength of the machine and prevent any springing of the column when the arm and spindle are at their maximum distances.

Arm.—The arm is made in pipe section, its upper brace being as close to the head as possible while the lower brace is at the outer edge. This arrangement tends to stiffen the arm for resisting upward torsional pressure from the spindle when drilling. The arm is carried from a top cap on the column, which rests on roller bearings and permits an adjustment covering the full circle about the column. Fixed binder levers permit the arm to be secured in any desired position. The elevating screw is provided with ball thrust bearings and the lowering speed of the arm is almost three times the elevating speed.

The Spindle.—The spindle is made of crucible steel, is ground and counterbalanced and has a quick advance and return. Provision has been made for taking up all wear in the bearings. The tapping mechanism is all controlled by means of a hand lever, shown in front of the head, which operates two self-adjusting, noiseless friction clutches on the back of the head. These clutches stop, start or reverse the spindle as desired. The design is such that it is impossible to accidentally engage both lever or automatic feed when tapping, thus avoiding the breaking of taps. An adjustable gauge nut causes the spindle to slip when the tap reaches the bottom of a hole.

The Automatic Feed.—The automatic feeding arrangement provides a positive feed for the spindle when high speed drills and reamers are in use and at the same time permits a friction feed being used when desirable, the change being made from one to the other by simply turning a nut. The small illustration, which is a view taken from the top of the spindle, shows the

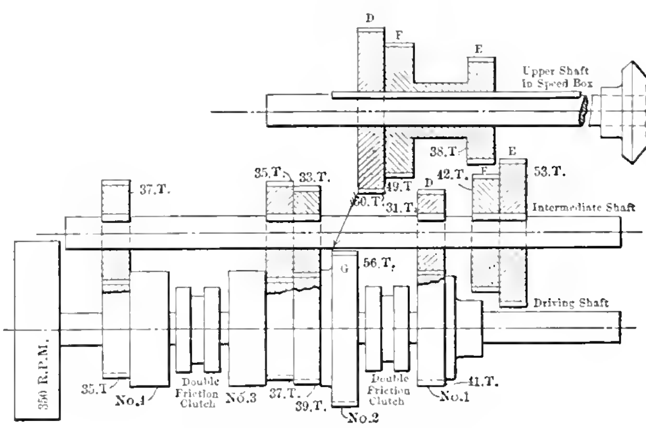
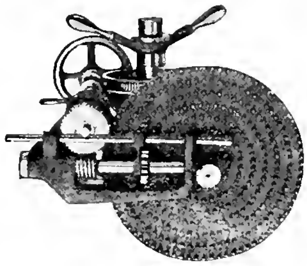


DIAGRAM OF GEARS IN SPEED BOX



AUTOMATIC FEED MECHANISM.

round plate having eight circles of steel pins, which is located above the spindle gear. These pins engage the steel pinion on the horizontal worm shaft and thus the speed of this shaft can be varied by running the pinion in and out from the center of the plate. A knob located below the lower hand wheel on the head controls the movement of this pinion by means of a sliding rack and gear. These eight changes of feed can be quickly made while the drill is at work. The upper worm wheel has its hub split and by means of a ring nut can be locked to the shaft for a positive feed and can be slightly released for a friction feed.

The automatic trip arrangement is provided with a safety stop which prevents the feeding of the spindle after it reaches the limit of its travel. A graduated bar on the counterbalance weight is set at zero when the drill enters and has several adjustable dogs to trip the feed as often as desired. The feed can also be tripped by a lever on the vertical feed rod.

The letters and numbers cast near the levers show the operator in which direction to move them to obtain the proper speeds. The speeds, together with instructions for operating the levers, are given on the plate attached to the machine.

This machine was designed and is manufactured by the Mueller Machine Tool Company, Cincinnati, O.

Longitudinal vs. Transverse Erecting Shops.—There is another feature in favor of the longitudinal shop which does not always receive the consideration to which it should be entitled, and that is that the cost per square foot of covered floor space is generally less with the longitudinal than with the transverse shop; as an example, we have an average cost per square foot of four longitudinal shops built within the last five years of $1.77, and an average of three transverse shops built in the same period of $2.78 per square foot; and while this difference is greater than would probably generally obtain, yet structural steel manufacturers claim that the transverse shop would cost at least twenty-five cents per square foot more than the longitudinal. As stated above, however, both styles of shop are in general use and both have their good points and their weak points, and the problem should be studied in connection with the environments and climatic conditions; and if the superintendent of the shop feels that he could obtain better results from one type than from the other, we believe that the shape of shop is so secondary to the question of organization that it should be held subordinate to the latter in every case.—*Mr. G. R. Henderson at the New England Railroad Club.*

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS JOURNAL.

Finishing Gas Engine Parts.—The Gisholt Machine Company, Madison, Wis., is issuing a leaf to be bound in its loose leaf binder, giving a detailed description, with line drawing, of the most successful method of finishing gas engine pistons and piston rings.

Electrical Apparatus.—The Fort Wayne Electric Works, Fort Wayne, Ind., is issuing several bulletins, among which might be mentioned bulletin No. 1,095 on the subject of enclosed alternating current multiple arc lamps. No. 1,094 on belted direct current generators, and No. 1,096 on type A transformers. Each bulletin is thoroughly illustrated and the descriptive matter is clearly and concisely written.

General Electric Company.—This company is issuing a number of bulletins descriptive of its products, among which are bulletin No. 4,509 on the subject of electric train lighting sets. These sets consist of direct connected turbines and generators suitable for application either on the locomotive itself or in the baggage car. They are thoroughly illustrated and described in this bulletin. Bulletin No. 4,504 is descriptive of tungsten lamps for street lighting. No. 4,516 is on the subject of MR circuit breakers for electric cars. No. 4,514 illustrates and describes the Thompson inclined coil portable indicating instruments. The voltmeters and wattmeters shown in this bulletin are constructed on the dynamometer principle and the ammeters on the mechanical vane principle.

New Rock Drill Catalog.—The Chicago Pneumatic Tool Company is issuing Catalog No. 22 illustrating and describing the "Chicago Giant" rock drills and kindred appliances. The book is printed in colors on high grade paper and contains 96 pages of matter. The text is well written and is embellished with half-tone engravings illustrating the rock drills and detailed parts, as well as several pages devoted to rock drill steels and a description of the method of lubrication used in these drills. Several pages are devoted to the Franklin air compressors, followed by illustrations and description of the "Baby Giant" and "One Man" rock drills and scenes showing the different drills in operation. The address of this company is Fisher Building, Chicago, Ill.

Progress Reporter.—The July issue of the "Progress Reporter" from the Niles-Bement-Pond Company, 111 Broadway, New York, contains the usual amount of interesting matter and excellent illustrations. This number is given up very largely to illustrations and descriptions of the new Pratt & Whitney 2½ x 26 in. open turret lathe, which includes many new features, especially a cross sliding turret. The machine is adaptable for a great variety of work from the bar and also on forgings and castings. A 10 ft. double rotary planing machine is also illustrated and briefly described, as well as a Pratt & Whitney automatic grinding machine for cylindrical work 5 in. in diameter and 48 in. long, and the Niles Gantry crane recently built for the Illinois Steel Company.

Metal Cut-Off Saw.—The Quincy Manchester Sargent Company, West Street Building, New York, is issuing several sheets suitable for binding in its loose leaf catalog binder, which illustrate and describe a new cut-off saw titled 1M. This saw has been designed to meet the demand for a somewhat smaller saw than the standard of this company and one which can be placed upon the market at a somewhat lower price, so as to be within the reach of the smaller shop. It has a capacity for rounds and squares up to 6 in. and for 10- in I beams. The saw blade is 18 in. diameter and the saw blade carriage has a travel of 10 in. This machine embodies all of the strength and wearing qualities of the regular construction and the sheets being issued contain four illustrations showing different views and arrangements of work on the machine.

Dayton Pneumatic Tools.—The Dayton Pneumatic Tool Company, 435 East 1st St., Dayton, O., is issuing a most attractive catalog descriptive of its products. It is a 47-page booklet printed on fine surface paper and thoroughly illustrated with half-tone and line drawing illustrations. The catalog opens with a description of several different designs of pneumatic hammers, each being illustrated and briefly described. Sectional views of the different hammers showing the operating parts are also included. Following this is found a section on pneumatic sand rammers, after which is a section on pneumatic drills. These are built in many sizes and designs, among which might be mentioned the close quarter drill, made in three sizes, and capable of working in very close quarters. The remainder of the catalog is given up to descriptions of other pneumatic appliances such as stay-bolt clippers, pneumatic cylinder hoists, rivet forges and Climax air compressors, which are shown both steam and belt driven, single expansion and compound, in many capacities. This company also furnishes some electric tools, illustrating a portable electric corner drill, a breast drill and a portable hand drill.

NOTES

Magnus Metal Co.—The following appointments have been made to take effect July 1, 1907: D. W. Ross, managing director; W. H. Croft, manager sales department, and W. S. Bostwick, general manager.

The Crocker-Wheeler Company.—In order to handle the largely increased amount of business in electric generators and motors in Southern Ohio, the Cleveland office of the above company has found it advisable to open a sub-office in the Columbus Savings and Trust Company Building, Columbus, O. This office will be in charge of Mr. Charles W. Cross, formerly of the Cleveland office.

A New Engineering Society.—A new society has been organized in Philadelphia called the Engineers' and Constructors' Club. Membership in this is limited to the engineers composing the organization of Dodge & Day. Its object is to discuss subjects relating to engineering and construction and to give all members the benefit of the experiences gained by each in his particular line. The proceedings of the club, giving the papers presented and the discussions, will be published. The officers of the club are H. T. Moore, president; George Walters, secretary. Managers, F. C. Andrews, H. T. Sanville, John E. Zimmerman and C. N. Lauer.

Westinghouse Electric Works.—During the month of May the Westinghouse Electric Company at East Pittsburg shipped 750 carloads of electrical machinery, an average of 30 carloads a day, aggregating 10,000 tons and representing in value about four million dollars. This exceeds, by 110 cars, any shipping record for one month that has ever been made at these works. The Westinghouse Machine Company also reached a high-water mark in May, having sent out from the works 90 engines, aggregating 50,000 h. p. This included gas engines from 10 to 1,000 h. p. and steam turbines from 1,000 to 10,000 h. p.

Electrical Show.—The New York annual electrical show will be held in the Madison Square Garden, September 30 to October 9 inclusive. At this show will be found exhibits of the latest equipment in electrical apparatus, as well as examples of standard practice of all of the well known electrical companies. It offers an exceptional opportunity for a person to cover the whole electrical field and familiarize himself with all the latest products by a very small expenditure of time. It is announced to prospective exhibitors that the price for space is very reasonable and that full particulars will be furnished by Mr. Geo. F. Parker, president, 116 Nassau St., New York.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

SEPTEMBER, 1907

A RATIONAL APPRENTICE SYSTEM.

New York Central Lines.

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PART III.

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Part II.

Entrance Qualifications.

Applicants for employment as apprentices must be not less than 17 or more than 21 years of age; preference is given, as far as possible, to the sons of employees. The applicant must pass a medical examination before the local medical officer, at the company's expense, proving him to be sound physically and mentally. His sight must be not less than 20/30 in each eye, he must be free from color blindness and his hearing must be not less than 20/20.

The applicant must have a good common school education, sufficient to enable him to read and write the English language and to make out his application on the blank provided for that purpose. He must have had sufficient training in simple arithmetic to enable him to do problems in addition, subtraction, multiplication and division of numbers to four figures and must have a reasonable knowledge of common and decimal fractions.

Credit in rate and time, not to exceed two years, may be given for previous work of the same class as that covered by the apprentice course. This credit, however, can only be given after the written approval of the superintendent of apprentices has been secured. The college graduate is given a time allowance for the work done in the college shop or during his summer vacation.

Applicants not showing an adaptability for the work should be dismissed from the apprentice course during the first six months and may be transferred to other employment.

The apprentices are selected from among the applicants by the chief officer of each shop in conjunction with a representative of the apprentice department. At one or two of the shops the applicant is given a written examination, but this is not encouraged. It is believed that the boys may be better sized up and that more satisfactory results are obtained by having the instructors engage the applicant in a simple conversation rather than by giving him a formal examination.

Examinations.

Examinations either for entrance or at any time during the course or at its completion are discouraged. The instructor, if he is the right kind of a man, can keep in such close personal touch with the boys that he knows far more as to their standing than could be determined by any formal examination. The courses are arranged so that a boy cannot successfully carry on the work unless he is thoroughly familiar with each step and the instructor has no trouble in determining whether he is qualified to take advance work or should be given additional exercises other than the problems which had been laid out in the regular course.

The success of this system of education depends largely on both of the instructors keeping in close personal touch with the apprentices and if a boy does not make an earnest effort to keep up with his work and take a reasonable interest in it, he is very soon detected and dropped from the service. On the other hand, some of the boys who may make the very best workmen in some branches have great difficulty in becoming proficient in certain parts of the work in the problem and drawing courses, but if they make an earnest effort and do good work in other respects their deficiency in this part of the work is overlooked.

Blackboard Exercises.

At frequent intervals the members of the class are sent to the blackboard, preferably just after the opening or just before the close of the session. The boys are given slips or cards containing the problems and thus each may have a different one. The instructor from the middle of the room, with the aid of a key, can easily and quickly determine whether the problems are worked out correctly, and as fast as one is completed can assign another. As the greater part of the problem work is done on the boy's own time, outside of school hours, these blackboard exercises enable the instructor to determine whether the boys are getting as much as they should out of their problem work and to see whether they really understand the work. By watching them carefully he can easily see which ones need help and where they are weak.

Because of the difference in the advancement of the boys in the working out of the problems it may not be feasible to send them all to the board at the same time, and if so, different sections may be sent to the board at different times, although the instructor, who knows just what problem sheet each boy is working on, can have the entire class go to the board at one time and give each apprentice examples of a grade to suit his requirements.

Lectures.

Lectures, in the sense in which the word is used in connection with college work, are not appreciated by the apprentices. Occasionally it is desirable for the instructor to take up certain features of the work with the class as a whole, but care is

N. Y. C. LINES.
RECORD CARD APPRENTICE SYSTEM.

NAME Harry H Smith.
SHOPS AT West Albany. N. Y. C. & H. R. R. R.

YEAR	1903-1904						1904-1905						1905-1906						1906-1907					
MONTH	CLASS OF WORK	DAYS WORKED	RATE	WORKMAN-SHIP	PERSON-ALITY	CLASS WORK	CLASS OF WORK	DAYS WORKED	RATE	WORKMAN-SHIP	PERSON-ALITY	CLASS WORK	CLASS OF WORK	DAYS WORKED	RATE	WORKMAN-SHIP	PERSON-ALITY	CLASS WORK	CLASS OF WORK	DAYS WORKED	RATE	WORKMAN-SHIP	PERSON-ALITY	CLASS WORK
4	General	24	8	4	C	C	Lathe & Miller	24	10	6	C	C	Air Brake	25	12	6	C	C	Motion Work	25	14	7	B	C
5	Mach Work	27		4	C	C	Slotter	25		6	C	C	" "	30		6	C	C	" "	30		7	B	C
6	" "	26		5	C	C	"	26		6	C	C	" "	24		7	C	C	" "	24		7	B	B
7	Drill Press	10		5	C	C	"	25		6	C	C	Steam Pipes	25		6	C	C	Guide and Steam Chest	12		7	B	B
8	" "	28		5	C	C	Tire Lathe	26		5	C	C	" "	26		7	C	C	Boiler Head Driving Boxes	26		7	B	B
9	" "	26		5	C	C	" "	24		6	C	C	" "	24		7	B	C	" "	24		7	B	B
10	Jumper	27		5	C	C	" "	30		6	C	C	General Pit Work	24		7	B	C	" "	30	16	7	B	B
11	"	23		5	C	C	Planer	28		6	C	C	" "	30		7	B	C	" "	28		7	B	B
12	"	28		5	C	C	"	27		6	C	C	" "	28		7	B	C	Round House	27		6	B	B
1	Bolt Lathe	28		5	C	C	"	30		6	C	C	Shoes & Wedges	27		7	B	C	" "	30		7	B	B
2	Lathe & Miller	32		6	C	C	Tool Room	25		6	C	C	" "	30		7	B	C	" "	26		7	B	B
3	" "	25		6	C	C	" "	26		7	C	C	" "	25		7	B	C	" "	25		7	B	B
TOTALS AND AVERAGES	YEAR COMPLETED Mar. 31, 1904						Mar. 31, 1905						Mar. 31, 1906						Mar. 31, 1907					
EST. OF STUDENT	Steady - Reliable Rather slow. Lacks confidence.						Will make a good man						Attended Eve. Class						Marked improvement in class work Judgement - Good					

WORKMANSHIP MARKS. REPORTED BY SHOP INSTRUCTOR. BASIS - 10 TO 1. (WHERE 10 IS PERFECT)

PERSONALITY MARKS. REPORTED BY SHOP INSTRUCTOR. BASIS - A. B. C. (SEE BELOW)

CLASS WORK MARKS. REPORTED BY DRAWING INSTRUCTOR. BASIS - A. B. C.

ESTIMATE OF STUDENT REPORTED BY INSTRUCTORS. (YEARLY REPORT)

A - EXCELLENT
B - GOOD
C - FAIR
D - UNSATISFACTORY
E - FAILURE

SUBSEQUENT SERVICE

Re-employed as Machinist at Depew Shops, April 15, 1907

APPRENTICESHIP COMPLETED March 31, 1907

MARKS FOR 4 YEARS: WORKMANSHIP - 6. PERSONALITY - B. CLASSWORK - C.

REPRODUCTION OF ONE OF THE APPRENTICE'S RECORDS.

taken at such times to cover only a small amount of ground, taking up one or two points only, to make the explanations clear and simple and to make the talk as informal as possible, asking the boys questions and carrying it on in a conversational style.

The apprentice department has secured a combination stereopticon and reflection lantern, which it is proposed to use in connection with the evening classes, and as the work becomes more advanced, it is expected that it can be used to advantage in connection with the regular apprentice classes.

At practically all of the schools the apprentices have had the benefit of instruction in the air brake instruction car or room.

Preparations are being made for a series of evening talks at the West Albany shops, which will be open to the apprentices and members of the mechanics' evening classes. The first talk of the series will be on the electric locomotive by Mr. J. G. Bauket, assistant superintendent of electrical equipment. This same plan will probably be worked out at the other schools.

Discipline.

The deportment of the apprentices, both in the school room and in the shop, is good. As they are paid for the time in the school room it is possible to enforce a strict discipline if necessary, although generally speaking the boys are so thoroughly interested in their work that the instructor has very little difficulty as concerns their conduct. Cases of poor deportment or unexcused absence from class are reported to the shop superintendent, and if necessary he takes the matter up with the offender. "Boys will be boys," and except in extreme cases more can usually be accomplished by directing their efforts to better things rather than by strictly enforcing a penalty or attempting to punish them. At the close of the school session the apprentices go directly to their work in the shop. The shop instructor usually assists in the class room and he sees that the boys report promptly to the shop.

The reports covering the apprentice's deportment, personality, and scholarship, which are considered in detail in the following section, are kept on record at the local shop and at the New York office, and are periodically reviewed by various officers, so that it is of course to the apprentice's advantage to see that these reports are as favorable as possible.

Records and Diplomas.

The record of each apprentice, from the time he enters the service until he completes his apprenticeship, is kept on file at the apprentice headquarters in New York, as well as at the local shop. Heavy cardboard cards, 8 x 10½ in. in size, are kept on file at the New York office, one side showing the record of the apprentice for each month, extending over a period of four years, and the other side giving general information as to his record. Both sides of one of these cards are reproduced. At the end of each week of service the shop instructor makes a record of the workmanship and personality of each apprentice, and the drawing instructor makes a record of the drawing room and class work. The monthly report is taken from these records.

The mark on workmanship is based on the quantity and quality of the work done in the shop and upon the skill and ability shown. The mark ten indicates perfect work; nine is not as good, and so on down to zero, which is the lowest.

The drawing room and class work mark is based on both the quantity and quality of the work done and on the apprentice's attitude toward his studies. The first five letters of the alphabet are used as follows:

A—Excellent, exceptionally good, to be given sparingly.
B—Good, better than the average, should be given only where there is special merit.
C—Fair, the average mark, and the one to be most commonly used.
D—Unsatisfactory, below the standard, means that improvement must be made.
E—Failure.

The personality mark is based on the attitude of the apprentice toward his work, his interest, evidence of ambition or lack of it, whether he is doing his best, his willingness to be instructed and his general character and habits. The first five letters of the alphabet are used as above.

The apprentices may learn their monthly marks by applying to the instructor at stated intervals. At the end of each year each apprentice receives a report showing his average marks for the year.

N. Y. C LINES.
RECORD CARD APPRENTICE SYSTEM.

NAME Harry H. Smith
SHOPS AT West Albany N.Y.C. & H.R.R.R.

NAME Harry H. Smith BORN 1-4-1885. AT Troy.
PRESENT ADDRESS (IN FULL) 19 Main St. Albany N.Y.
LIVING AT HOME OR BOARDING Home PARENTS OCCUPATION Engineer
EDUCATION. YEARS IN GRAMMAR SCHOOL All. COURSE COMPLETED Yes
YEARS IN HIGH SCHOOL 1. EVENING COURSES ATTENDED Nine
YEARS SINCE LEAVING SCHOOL BEFORE STARTING AS APPRENTICE 2
PREPARATION IN ARITHMETIC All ALGEBRA Simple Equations.
OTHER SUBJECTS

ENTERED SERVICE Dec. 1902 AT Ravena AS Round House Helper.
RATE 16 SERVICE TERMINATED March 31, 1907.
SUBSEQUENT SERVICE

COMMENCED APPRENTICESHIP April 1, 1903. CLASS Machinist.
COMPLETED APPRENTICESHIP
REMARKS Father employed as engineer 6 years.
Uncle, painter in car shops, 10 years.
Made captain of apprentice ball team 1905-6.

REAR SIDE OF REPORT OR RECORD CARD.

At the end of each year the instructors draw up an estimate of the personality and progress of each apprentice. This is made up of the answers to the following questions, the first six of which are to be answered by the words "yes" or "no.":

1. Does he work overtime on drawing or problems?
2. Is he the type of boy we wish to have in our employ?
3. Is his attitude toward his employers good?
4. Does he spend his time well outside of shop hours?
5. Have you, or has the shop instructor, succeeded in gaining his confidence; *i.e.*, would he come to you first in trouble of any kind?
6. Can you recommend him at present to start in the company drafting room, or will he qualify during the next year? (Give probable date.)
7. What is his strongest point, or for what type of work is he best fitted?
8. What is his weakest point, or for what type of work is he least fitted?
9. Does he live at home, or board?
10. What is his address?

In addition to this information the instructor is expected to call attention to any items of interest such as special work which has been done by the apprentice, conditions at home, handicaps, or any facts which might be used in recommending a boy for a position. This report is not expected to be in any way based upon the monthly reports which are sent in by the instructors, but it is expected to be the instructors' personal estimate of the apprentice. The report is not supposed to be official and is not made through the local officer, but is sent directly to the superintendent of apprentices.

When the apprentice has completed his course he is presented with a certificate, which is suitable for framing, and which is reproduced on a small scale in the accompanying illustration.

Incentives to Promote and Hold Interest.

There are many incentives to encourage the apprentice in his work. The drawing and problem courses are made as interesting as possible; they deal with no abstract theories, but all of the exercises and problems are in connection with practical work in the shop. In most instances there is more or less rivalry among the apprentices as to their progress in this work.

In connection with the annual estimate of the personality and progress of each apprentice the instructors are asked to make special mention of those who have made exceptionally good progress or who have distinguished themselves either on some special piece of work or in class work. The superintendent of apprentices writes a personal letter of commendation to each of these boys and naturally these letters are very highly prized by the recipients. On New Year's Day of this year 45 such letters were sent out.

As an additional incentive it is quite probable that, after the schools have been established for a long enough period so that the apprentices will have been able to complete the course in drawing and problem work, a few of the brighter graduate apprentices will be sent, at the company's expense, to a technical school for a year to finish off their course. Such men will be admirably prepared for work in the motive power department.

At most of the shops the apprentices who show a liking for mechanical drawing are assigned for a month or two, during their apprenticeship, to assist the shop draftsman and usually the apprentice is allowed to place his name on all the drawings he makes. These are of course commented upon when they come to the attention of the men in the shop and the boys take more or less pride in having done such work. In several instances apprentices who have made especially good records and have about completed their apprenticeship are given the privilege of being transferred to the main drawing room of the road and in a couple of instances the boys have been sent to the main drawing room at New York after they have completed their course.

At two of the shops the apprentices have been taken in a body, under the direction of the instructors, to visit neighboring shops or large manufacturing establishments, for instance, at the West Albany shops the apprentices have visited both the American Locomotive Works and the General Electric Company's works at Schenectady.

At some of the smaller shops where the boys are not able to round out their courses to advantage they will be assigned to

larger shops for the fourth year, for instance, the boys in the car department at East Buffalo will probably have an opportunity of spending a year at the West Albany shops in order to get experience in repairing passenger cars.

The shop superintendents encourage the boys by occasionally assigning them to special work where they can apply the knowledge in drawing or mathematics, which they have gained in the class room. One shop superintendent, who is very much interested in the apprentices, makes a point of occasionally stopping and asking an apprentice something about the work which he is doing that will make him appreciate the application of what he is learning in the class room.

Attitude of the Men.

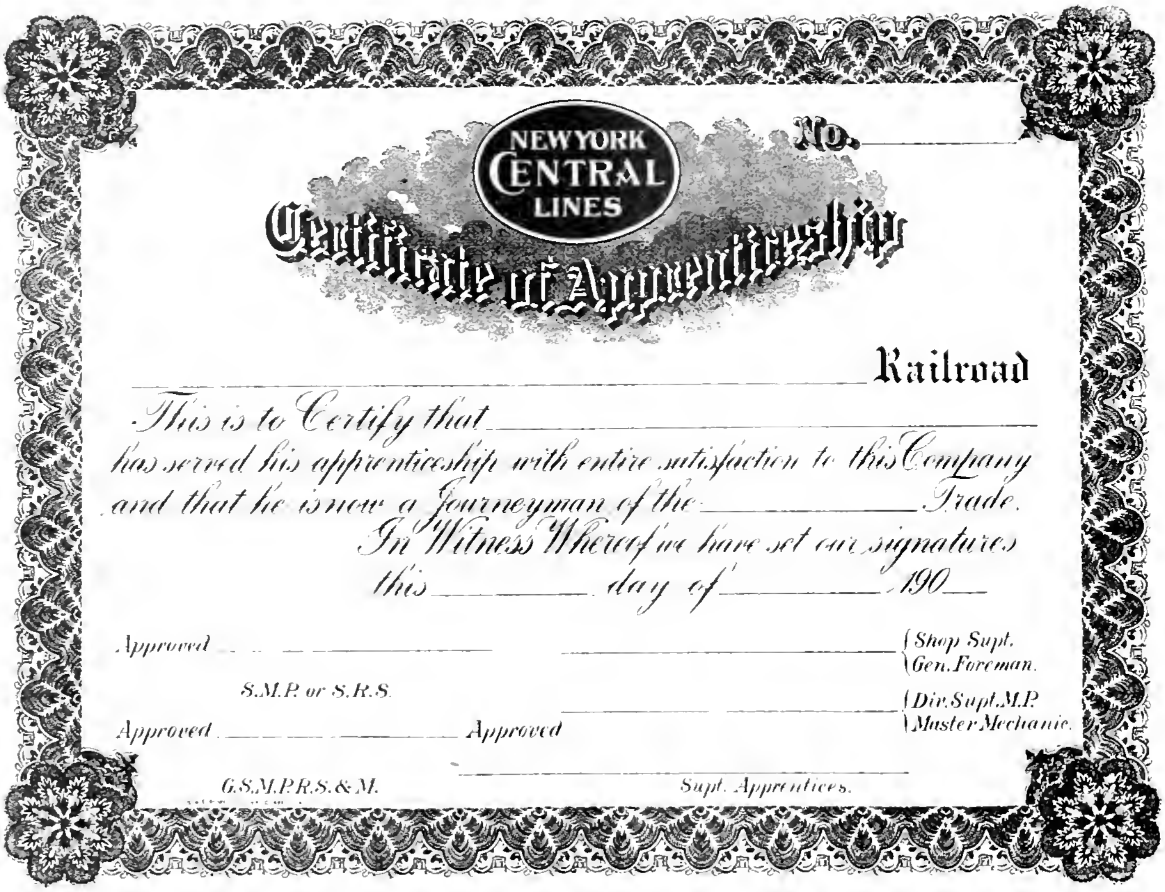
The workmen are taking a great deal of interest in this new development and look upon it with considerable favor. There has been very little incentive during the past few years for boys to enroll as apprentices, and the men are glad to have an opening for their sons by which they can be assured of a thorough training which will make them first-class mechanics, and which if properly followed up may fit them for positions of authority and responsibility. Due to the neglect of a proper system for recruiting men the percentage of skilled mechanics has been very sadly decreased and the good all-round mechanic has almost been lost sight of. A system that will build up men of this kind, and thus add dignity and importance to the position of the mechanic, is to be welcomed.

Attitude of the Officers.

The officials, from the gang boss to the superintendent of motive power, seem to be very much pleased with the new system. It means that they are going to have more efficient men under them and that the problem of issuing and executing orders will be simplified. The boys, coached by the shop instructor, are doing better work and more of it, and the amount of spoiled work, which is always an item where there are many boys in the shop, is being reduced to a minimum. The problem of securing and holding apprentices has been solved, and in a few years the problem of securing good all-round mechanics will, to some extent at least, also be solved. A point blank question addressed to various officials, as to whether such a system was worth while and really paid, was met by a very enthusiastic response that of course it did, and in most cases they were ready to advance good reasons as to why this was so.

It is interesting to note the attitude of different officials as they enter the school room when a class is in session. One superintendent of motive power always promptly removes his hat, as he considers that the school room is on the same plane as a college recitation room and deserving of the same respect and dignity.

At every point questioning brought out the fact that the higher officials quite often stop in at the school room and usually examine the work the boys are doing, occasionally asking questions or in some way showing their interest in the work. It is these little things, that are so easy to do and yet so easy to be left undone, that impress and encourage the boys.


NEW YORK CENTRAL LINES

No. ____

Certificate of Apprenticeship

____ Railroad

This is to Certify that ____
has served his apprenticeship with entire satisfaction to this Company
and that he is now a Journeyman of the ____ Trade.
In Witness Whereof we have set our signatures
this ____ day of ____ 190__

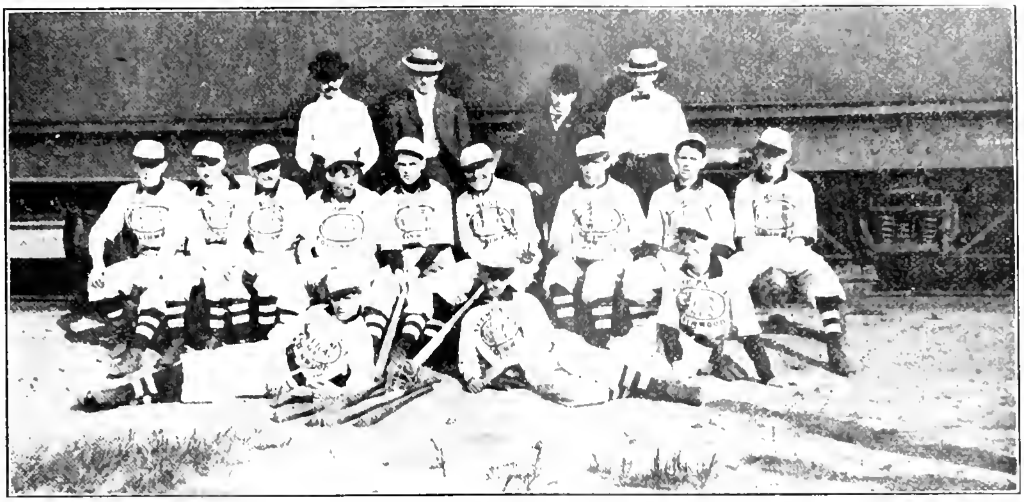
Approved ____ ____ Shop Supt. / Gen. Foreman.
S.M.P. or S.R.S. ____ Dir. Supt. M.P. / Master Mechanic.
Approved ____ Approved ____
G.S.M.P.R.S.& M. Supt. Apprentices.

REDUCED FACSIMILE OF DIPLOMA.

The Car Department.

It has usually been considered impossible to maintain an apprentice system in the car department and recruit the force, other than the laborers and helpers on the repair track, from its ranks, and this is especially true where freight car work only is handled. That an apprentice system has been established at East Buffalo, a point where up to the present time only freight car repair work has been done, is worthy of notice. It was said to be impractical to introduce such a system at that point, but at the present time there are five regular apprentices and the indications are that this number will be considerably increased in the near future.

In starting this school a number of laborers and helpers were collected together and were guaranteed a special course if they would enroll themselves in the school and attend its sessions. Many of them realizing the advantages to be thus gained enrolled themselves, and with this start made it was not a difficult matter to secure apprentices because of the advantages which



APPRENTICES' BALL TEAM—COLLINWOOD SHOPS.

were offered. On May 1 there was one blacksmith, one tin and coppersmith, two machinists and one carpenter apprentice in addition to thirteen laborers who were enrolled in the school.

Special courses, both drawing and problem, have been arranged, although a considerable part of the work in the locomotive courses is suitable for the car department apprentices.

Apprentice Auxiliaries.

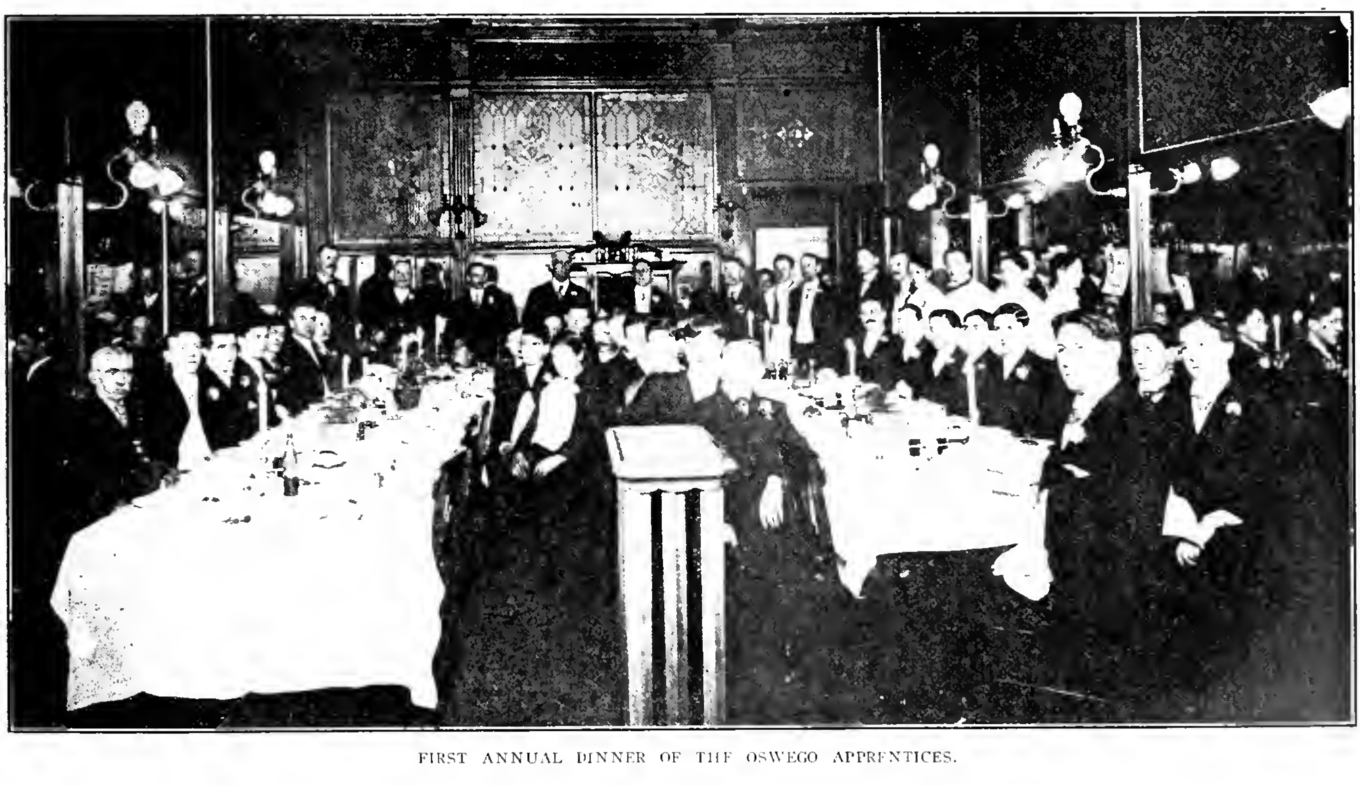
At several of the shops the apprentices have formed organizations of their own for social purposes. The boys at Oswego have organized and started the custom of having an annual dinner. The first one was given on April 23 of this year and to it were invited the superintendent of apprentices and his assistant from New York, the superintendent of motive power at Oswego, Mr. W. O. Thompson, and the various foremen in the mechanical department. Short addresses were made by the invited guests and by some of the boys and the evening passed off very successfully.

At Elkhart the apprentices have an organization and each year arrange for a camping trip. This is also true of the West Albany shops. The apprentices at Elkhart and Collinwood have organized ball teams. At Collinwood a diamond has been laid out on the shop property. Two games have been played between the Collinwood and Elkhart teams, and the Collinwood team has had a game with the shop officials.

It is expected that an apprentice button will be worked up which the apprentices on the system will be entitled to wear.

To Carry Oil Through Rifled Pipe.—Contracts have been let by the Southern Pacific Company for the building of an oil pipe line 250 miles long from its oil properties in Kern County to a point near Port Costa on San Francisco Bay. The pipe will be rifled on the same principle as a gun barrel, the idea being that the swirling motion given to the oil will make pumping easier. Experiments have demonstrated that the rifled pipe will carry a stream of 20,000 barrels of fuel oil every twenty-four hours, and make it possible to locate the pumping stations about 25 miles apart, a much greater distance than possible heretofore. The rifled pipe is the invention of two Southern Pacific engineers.

All-Steel Box Cars.—The Union Pacific Railroad has just ordered 25 all-steel box cars, similar to the experimental car described on page 129 of our April issue, to be constructed immediately. With a capacity of 50 cubic feet more than that of the standard Union Pacific wooden box car, the steel car weighs two tons less—37,800 pounds. Actual tests have shown that the one-eighth inch sheet steel forming the sides and ends of the car is stronger than the wood ordinarily used.



FIRST ANNUAL DINNER OF THE OSWEGO APPRENTICES.

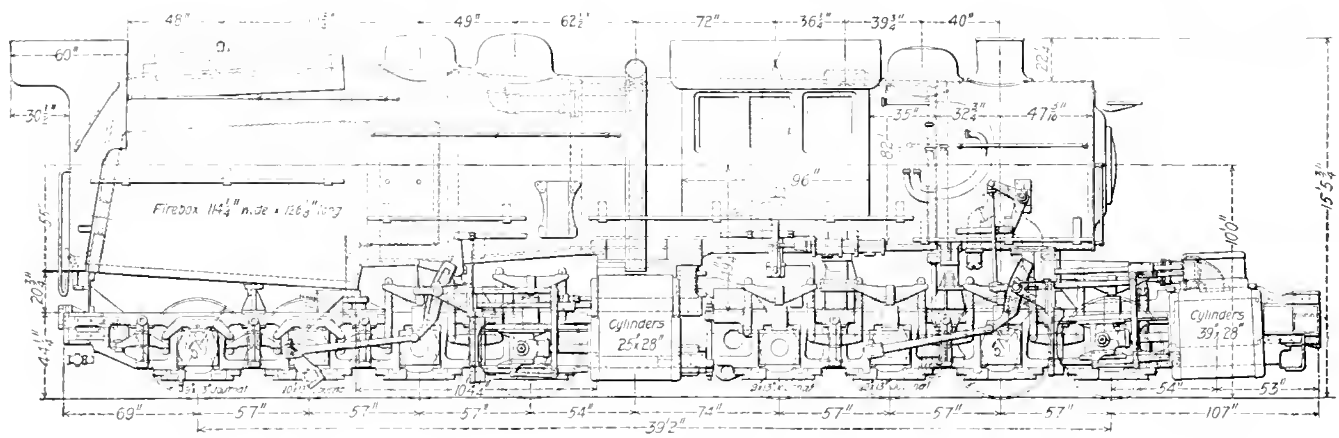
LARGEST LOCOMOTIVE IN THE WORLD—ERIE RAILROAD

MALLET ARTICULATED COMPOUND LOCOMOTIVE, 0-8-8-0 TYPE.

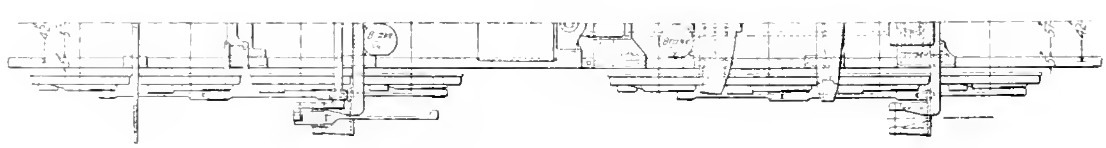
ERIE RAILROAD.

All records of weight, size and power of locomotives have been broken by the completion at the Schenectady Works, of the American Locomotive Company, of the first of an order of three pushing lcomotives for the Erie Railroad. These locomotives weigh 409,000 lbs., all of which comes on the eight pairs of drivers. They have a boiler measuring 84 ins. outside diameter at the front end, containing 21 ft. tubes and a 4 ft. combustion chamber and a firebox with 100 sq. ft. of grate surface, in which soft coal will be burned. The tractive effort operating as a compound is 94,800 lbs. The locomotive and tender measure nearly 85 ft. in length, over all. It is nearly 15½ ft. in height and has a width of 11 ft. at the low pressure cylinders.

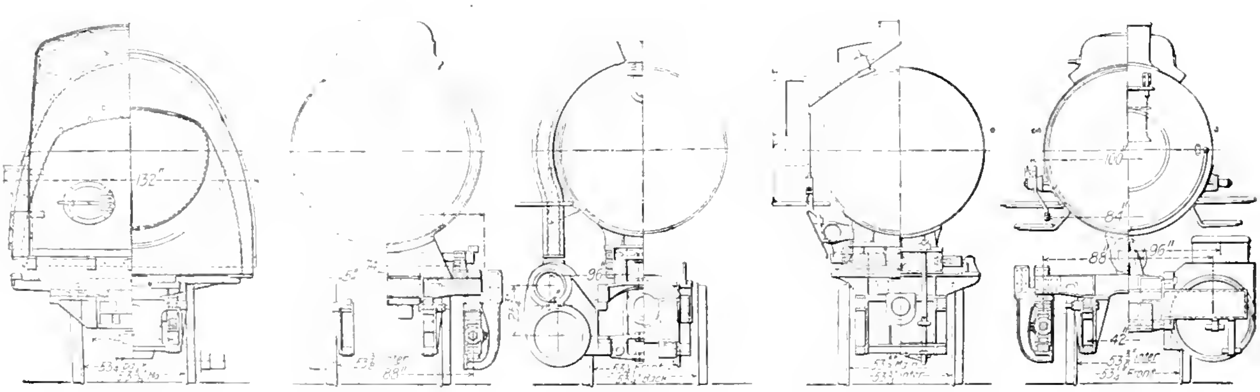
The first locomotive of this type to be built in this country was constructed a little over three years ago by the same company for the Baltimore & Ohio Railroad. At that time the design was looked upon with considerable suspicion by many railroad men. However, after being exhibited at the St. Louis Exposition the locomotive was put into pushing service on the mountains and within a comparatively short time proved to be a complete success in every respect. The present locomotive, while exceeding the Baltimore & Ohio engine by 65,000 lbs. in weight and nearly 24,000 lbs. in tractive effort, is of practically the same design in all of its essential details. Two other designs of the same type have been brought out in this country, both being for the Great Northern Railroad, one designed for pushing service and the other for regular road service. They were built by the Baldwin Locomotive Works. These engines, however, differ from the two designs just mentioned in having two-wheeled trucks, front and rear, making them of the 2-6-6-2 type. While they have been in service a comparatively short time the evidence is sufficient to show that they will be successful



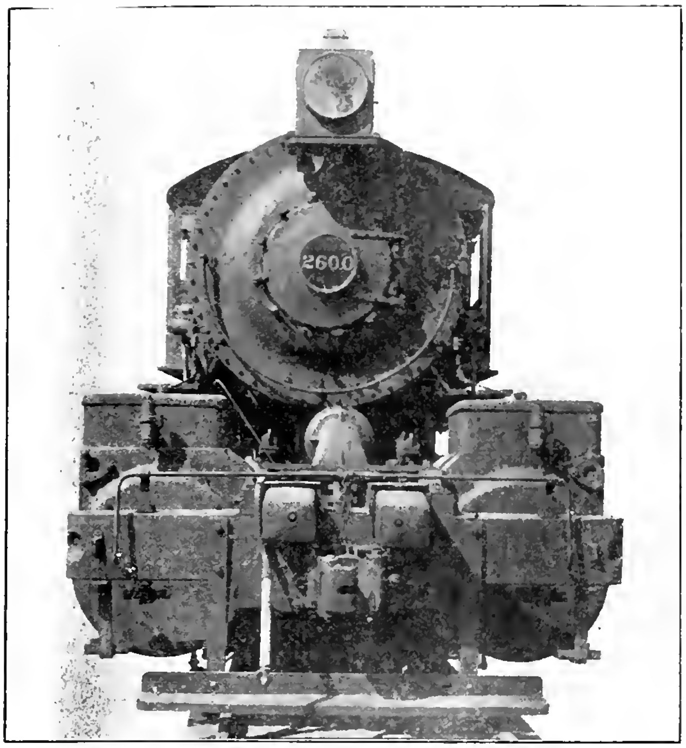
SIDE ELEVATION.



HALF PLAN OF RUNNING GEAR.



CROSS SECTIONS OF ERIE MALLET COMPOUND LOCOMOTIVE.



FRONT VIEW—ERIE MALLET COMPOUND.

for the service intended. Hence, while the Erie engine is of a weight and size which a short time ago would have been considered practically impossible for a locomotive, it cannot really be looked upon as experimental, and all indications are favorable to its successful operation. They will be used in pushing service between Susquehanna and Gulf Summit, where the ruling grade is 1.3 per cent. A tractive effort of nearly 95,000 lbs. should be capable of handling about 2,000 tons, exclusive of the locomotive, on this grade.

The Mallet articulated compound type of locomotive has been described several times in this journal and reference can be made to previous articles, as shown in the accompanying table, for such descriptions. The term, Mallet compound, applies only to the arrangement of the cylinders and driving wheels with separate sets of frames connected through a hinged joint, and does not include any particular design of compounding as concerns the distribution of steam. The Erie locomotives and also the one on the Baltimore & Ohio, are compounded on the Mellin system,* which employs an automatic intercepting and reducing valve for admitting live steam at a reduced pressure to the low pressure cylinders in starting, and for increasing the pressure in those cylinders at any other desired time. The locomotives on the Great Northern Railway are designed with a plain system of cross-compounding without intercepting valves or other automatic arrangements, having, however, a small pipe connection from the boiler to the receiver pipe, by means of which live steam can be admitted at the discretion of the engineer.

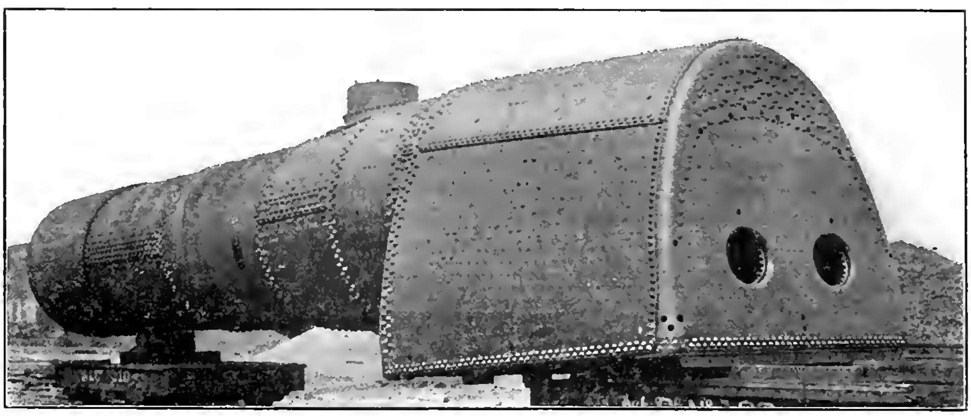
The accompanying table will permit a comparison to be made between the four designs in use in this country. In considering the ratios shown in this table it must be remembered that the boiler of the Erie engine is fitted with a 4 ft. combustion chamber, which considerably reduces the amount of total heating surface in comparison with its size and grate area. The indications from the service already given by combustion chamber locomotives are that the efficiency and the power of the boiler are not reduced by this installation, and hence the ratios of but 53 sq. ft. of heating surface per sq. ft. of grate area, and of but 222 per cu. ft. of cylinder volume do not really indicate that the boiler is not of sufficient size as compared with those of the other designs.

In spite of the fact that this locomotive weighs 409,000 lbs. it has a weight per driving axle which is less than many large freight locomotives now in service and less than any previous Mallet compound locomotive, except the ones for road service on the Great Northern Railway. One of the features of greatest advantage of the Mallet type is that an enormous amount of power can be centered in one machine which will be capable of operating over the same track that other heavy freight locomotives use.

The construction of the boiler is clearly shown in the illustrations, and it is easily seen to be an enormous source of power.

Owner	Erie	G. N.	B. & O.	G. N.
Type	0-8-8-0	2-6-6-2	0-6-6-0	2-6-6-2
Builder	Amer.	Bald.	Amer.	Bald.
Total weight, lbs.	409,000	355,000	334,500	288,000
Weight on drivers, lbs.	409,000	316,000	334,500	250,000
Tractive effort, lbs.	94,800	71,600	70,000	57,760
Diameter cylinders	25″ & 39″	21½″ & 33″	20″ & 32″	20″ & 31″
Stroke	28″	32″	32″	30″
Diameter Boiler	84″	84″	84″	72″
Steam pressure, lbs.	215	215	235	210
Diameter drivers	51″	55″	56″	55″
Total heating surface, sq. ft.	5313.7	5703	5600.	3906.
Total weight ÷ total H. S.	76.9	62.	59.5	73.8
Total H. S. ÷ vol. cylinders	222.	275	295.	229
Total H. S. ÷ grate area	53.	73	77.3	73
B. D. factor	910.	690	700.	813.
Reference in THE AMERICAN ENGINEER	This issue.	1906, p. 371	1904-p 237-262	1907 p. 213

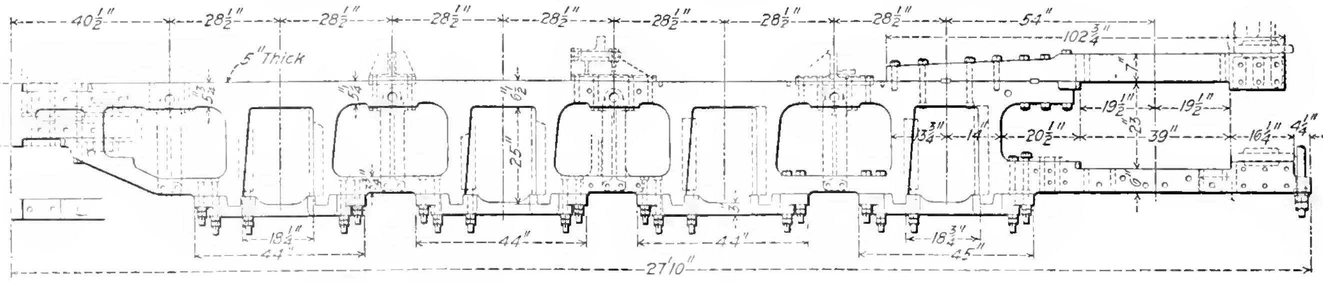
It is of the radial stay type with conical connection sheet, the inside diameter of the first ring being 82 in. and that of the largest course being 96 in. The heaviest ring of the shell is 1 3/16 in. thick. A steam pressure of 215 lbs. is carried. The tubes, of which there are 404, are 21 ft. long and are 2¼ inches in diameter. This length of tube, taken in connection with the 4 ft. combustion chamber, places the front tube sheet 25 ft. from the firebox, a figure which has never before been equaled in locomotive service. The combustion chamber itself is radially stayed from the shell of the boiler, and is provided with ample water space on all sides. The mud ring is 5 in. in width at all points, and the crown sheet has a slope of 5 in. from its connection to the combustion chamber to the door sheet. The dome is placed about central in the length of the boiler, since the locomotive is to operate in either direction and on heavy grades.



BOILER OF ERIE MALLET COMPOUND LOCOMOTIVE.

A novel design of throttle valve has been fitted to these locomotives, which in addition to taking steam at the top only, also acts as a steam separator. This construction is shown in one of the illustrations, and the arrangement is such that the entering steam strikes against the curved surface of the upper bell upon which the entrained water will be deposited, and following the surface of this casting will pass down through the center of the valve to an outlet below. The top of the bell casting does not take a bearing, and hence it does not in any way act as a

* For description of this system see AMERICAN ENGINEER AND RAILROAD JOURNAL, April, 1906, p. 130.



REAR FRAME—ERIE MALLET COMPOUND LOCOMOTIVE.

valve. The steam is led from the throttle pipe through a short dry pipe to a point directly above the high pressure cylinder, where it passes through the shell to a T head on top of the boiler, and thence through wrought-iron steam pipes on either side to the top of the high pressure steam chest.

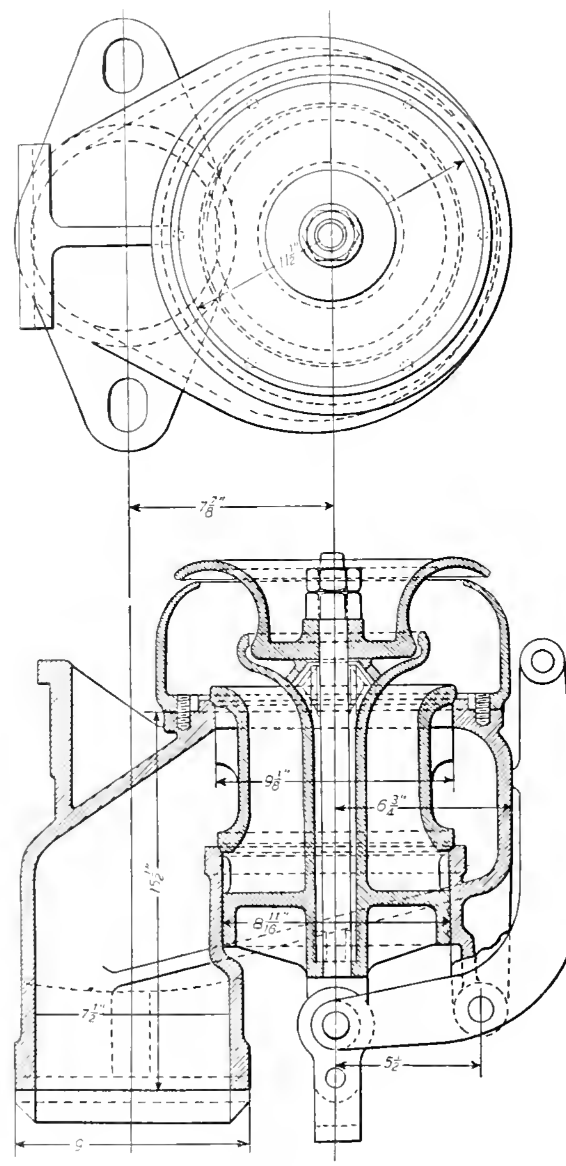
Owing to the extreme width of the firebox it was necessary to place the cab over the boiler shell near the front, and hence all the controlling apparatus, injectors, etc., are located on the right hand side. The injectors feed through a double check valve located on the center line of the boiler, but a short distance back of the front tube sheet.

The high pressure cylinders are very similar to those used on the Baltimore & Ohio locomotive. They are cast in pairs with saddles, the separation between the two cylinders, however, being 8½ in. to the right of the center. This permits the intercepting valve to be placed in the left-hand cylinder casting and also gives room for the connection to the receiver pipe. The exhaust steam from the right cylinder continues from the passage in its saddle to an outside U-shaped pipe connecting to a passage in the left-hand cylinder casting which leads up to the intercepting valve chamber into which the exhaust steam from the left cylinder also passes. From this point the exhaust steam passes to a 9 in. receiver pipe extending forward between the frames to the low pressure cylinders. An extra exhaust connection is provided in the side of the left cylinder casting, which has a 4½ in. pipe leading to the exhaust pipe in the smokebox. This connection is made by a pipe having universal joints in a manner similar to the receiver pipe. The construction of the receiver pipe is such as to permit free movement of the front frames in all directions, it being fitted with a ball joint at either end and a slip joint near the forward end. It is arranged to permit the locomotive to pass around 16-degree curves. The low pressure cylinders are cast in pairs, the connection to the receiver pipe being made through a Y-shaped casting connecting at the back to the cored passages in the cylinder. The exhaust is carried through an elbow located on top, and in the center, to a short pipe with universal joints leading to the exhaust pipe in the front end.

The high pressure cylinders are fitted with piston valves having internal admission while the low pressure cylinders have balanced slide valves with external admission. The valve gear, which is of the Walschaert type, is so arranged that the return crank leads the pin in both sets, and hence the block is at the bottom of the link for the go-ahead motion for the low pressure cylinders and at the top of the link for the high pressure cylinders. In this way the weights of the two valve gears counterbalance each other. The operation of reversing is further assisted by a pneumatic reversing device, which is connected to the reverse lever and consists of two cylinders, one of which contains oil under pressure for locking the device in any desired position, the other cylinder being the air cylinder. The operation of this device is controlled from an auxiliary reversing lever in the cab.

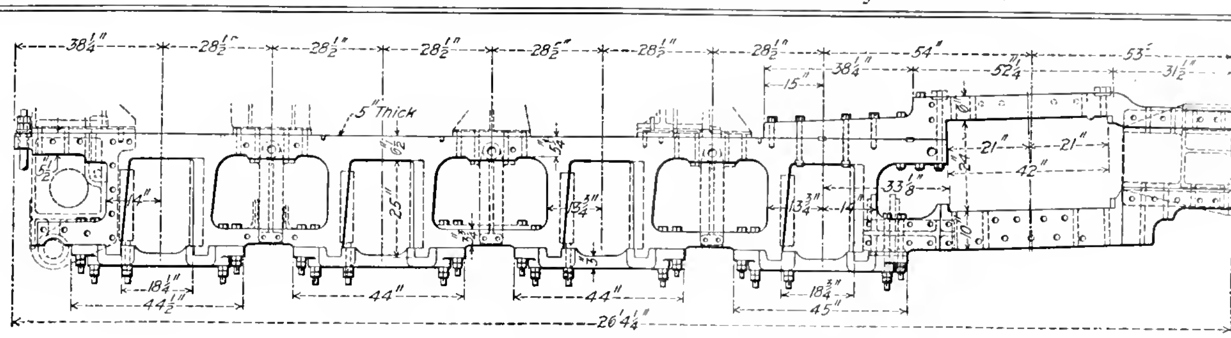
The construction of the cast-steel frames is shown in one of the illustrations and needs no explanation. Special care has been given to obtaining a thorough system of cross bracing. The articulated connection between the two groups is made in practically the same manner as was used on the Baltimore & Ohio locomotive, the hinge joint being formed in castings secured ahead of the high pressure cylinder. The vertical bolts connecting the upper rail of the front group with the lower rail of the rear group are fitted with ball joints to permit free movement of the two frames relative to each other, and are provided for holding the frames in line and preventing binding on the hinged connection.

The weight of the boiler extending beyond the high pressure cylinder saddle is transferred to the front set of frames at two points, which are normally in contact, and two other points, which will come into contact under unusual conditions. The one



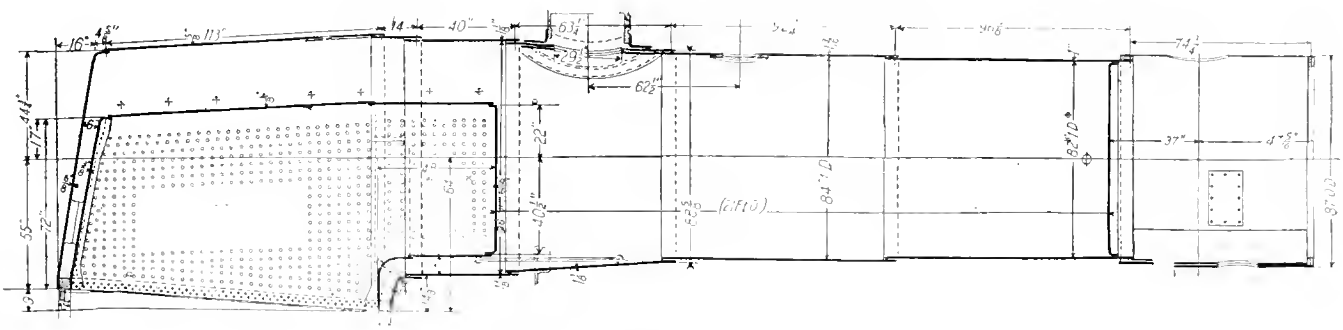
THROTTLE VALVE.

which carries the largest amount of weight has a self-adjusting sliding bearing, and is located between the third and fourth pair of drivers. This bearing will permit free movement in all directions in the horizontal plane, and also includes a safety connection which prevents the frames from dropping away from the boiler in case of any derailment. There is also a similar safety connection provided at the front end of the boiler between the guide yoke casting and the exhaust pipe elbow. The other support between the boiler and frames is located between the second



FRONT FRAME—ERIE MALLET COMPOUND LOCOMOTIVE.

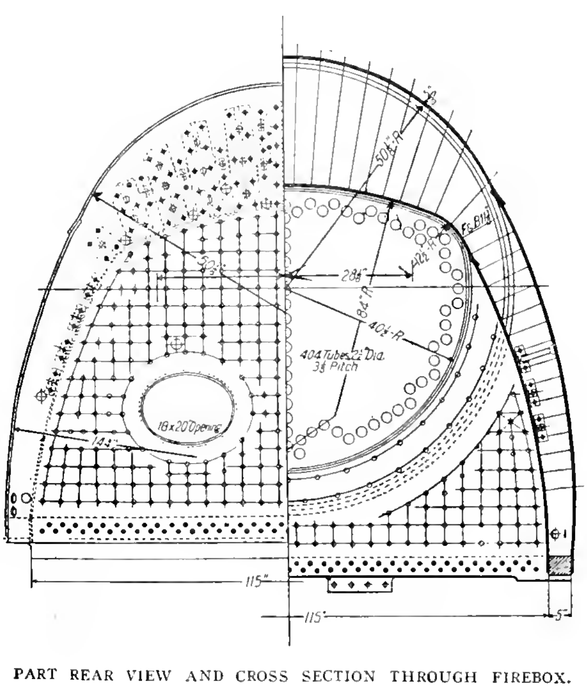
and third pair of drivers and consists of two vertical columns located just inside the frames and fitted with ball joints at either end. The upper end takes a seat in projections on the casting fastened to the boiler and the lower end seats in castings having one end hinged below a frame cross tie across the lower rails. These hinged castings are held in place by U-bolts at the opposite end, which pass up through the cross tie and are supported on coiled springs. In this manner a flexible connection is formed by the use of comparatively light springs and this support will take a varying load corresponding to the location of the frames with reference to the boiler. The initial compression of these springs is 30,000 lbs., and can be varied as found desirable.



LONGITUDINAL SECTION THROUGH THE BOILER.

A spring centering device is located between the second and third pair of drivers just ahead of the column support mentioned, and is provided with coiled springs for bringing the front group into line after leaving a curve. This construction also includes an emergency bearing which is normally separated about ½ in.

The front group of driving wheels are equalized together on each side and cross equalized in front of the forward drivers, thus making this system equivalent to a single supporting point. Each side of the rear engine is equalized independently. The locomotive is fitted with two New York duplex No. 5 air pumps and carries four air reservoirs located on top of the firebox and arranged as shown in the illustration. The general dimensions, weights and ratios are as follows:



PART REAR VIEW AND CROSS SECTION THROUGH FIREBOX.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Pushing
Fuel	Bit. Coal
Tractive effort, compound	94,800 lbs.
Weight in working order	409,000 lbs.
Weight on drivers	409,000 lbs.
Weight of engine and tender in working order	572,000 lbs.
Wheel base, driving	39 ft. 2 in.
Wheel base, total	39 ft. 2 in.
Wheel base, engine and tender	70 ft. 5½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.32
Total weight ÷ tractive effort	4.32
Tractive effort × diam. drivers ÷ heating surface	910.00
Total heating surface ÷ grate area	53.14
Firebox heating surface ÷ total heating surface, per cent	6.46
Weight on drivers ÷ total heating surface	76.90
Volume both cylinders, cu. ft.	24.00
Total heating surface ÷ vol. cylinders	222.00
Grate area ÷ vol. cylinders	4.17

CYLINDERS.

Kind	Mellin compound
Number	4
Diameter	25 and 39 in.
Stroke	28 in.

VALVES.

Kind, H. P.	Piston
Kind, L. P.	Richardson Bal. Slide
Greatest travel	5½ in.
Outside lap, H. P.	1⅛ in.
Outside lap, L. P.	1 in.
Inside clearance	¼ in.
Lead in full gear	3/16 in.

WHEELS.

Driving, diameter over tires	51 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 × 13 in.
Driving journals, others, diameter and length	9 × 13 in.

BOILER.

Style	Straight, with Conical Connection
Working pressure	215 lbs.
Outside diameter of first ring	84 in.
Firebox, length and width	126¼ × 114¼ in.
Firebox, plates, thickness	⅜ and ½ in.
Firebox, water space	5 in.
Tubes, number and outside diameter	404—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4,971.5 sq. ft.
Heating surface, firebox	343.2 sq. ft.
Heating surface, total	5,313.7 sq. ft.
Grate area	100 sq. ft.
Smokestack, diameter	18 in.
Smokestack, height above rail	15 ft. 5¾ in.
Center of boiler above rail	120 in.

TENDER.

Tank	Water Bottom
Frame	12 in. 40 lb. Channels
Wheels, diameter	33 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	8,500 gals.
Coal capacity	16 tons

SOME IMPORTANT RESULTS FROM THE PENNSYLVANIA RAILROAD TESTING PLANT AT ST. LOUIS.

FREIGHT LOCOMOTIVES.

Locomotive.	Speed, miles per hour.	Rev. per min.	Cut off per cent. of stroke.	Steam pressure, Lbs.	Ind. horse power.	Dyna-mometer horse power	Dyna-mometer pull, Lbs.	Total moist coal per hr.	Total dry coal per hr. Lbs.	Dry coal per sq. ft. grate area per hour.
No. 1499	6.7	40.4	30.45	203.4	454.	373.5	20,864	1383.	1368.	27.8
2-8-0 Type	13.4	80.7	39.34	201.4	930.	789.2	22,078	3489.	3448.	70.07
P. R. R.	20.	120.6	33.96	193.1	1036.	848.6	15,883	4083.	4041.	82.11
	26.7	160.9	32.91	185.9	1050.	774.2	10,863	4672.	4627.	94.04
No. 734	7.52	40.11	41.27	199.6	550.4	491.8	24,522	2049.4	2027	60.03
2-8-0 Type	14.99	80.	40.69	204	962.5	894.6	22,371	4199.7	4152.	122.97
L. S. & M. S.	22.28	118.9	35.70	189.4	1098.2	957.3	16,104	......	......	......
	30.04	160.32	27.37	199.4	1053.9	896.8	11,188	4726.3	4695.	139.04
No. 555.	7.49	40.01	48.6	210.1	512.	481.6	24,105	1084	1073.	21.70
2-8-0-C Type	14.98	79.98	57.5	210.9	1040.7	980.	24,539	2584.	2559.	51.77
M. C.	29.96	159.97	64.3	175.1	1001.3	859.7	10,762	3905.	3876.	78.41
No. 929.	6.714	39.97	40.8	213.5	633.6	557.3	31,131	1764	1751.	29.98
2-10-2-C Type	13.652	81.283	51.4	213.5	1257.9	1136.2	31,240	4343	4299.	73.61
A. T. & S. F.	10.184	60.639	41.9	216.7	888.8	787.6	29,005	2401.	2381.	40.77

Locomotive.	Total water evap. per hr. Lbs.	Total dry steam per hr. Lbs.	Dry Steam per sq. ft. H. S. Lbs.	Dry steam per lb. of dry coal. Lbs.	Lbs. steam per I. H. P.	Lbs. steam per D. H. P.	Temp. of fire-box.	Temp. of smoke-box	Draft front of dia-phragm.*	Effic. of boiler	Machine effic. loco	Heat effic. loco
No. 1499	12,915	12,823	5.17	9.373	27.29	33.21	1,480	581	......	77.45	82.18	5.13
2-8-0 Type	23,656	23,454	9.45	6.802	24.7	29.12	1,766	685	3.6	53.15	84.82	4.01
P. R. R.	25,192	24,982	10.06	6.83	23.74	28.98	2,001	724	4.66	50.59	81.91	3.84
	26,007	25,722	10.36	5.558	24.15	32.76	2,110	715	3.91	45.47	73.71	2.95
No. 734	15,713	15,549	6.119	7.671	27.31	30.57	1,992	551	3.06	58.57	89.35	4.25
2-8-0 Type	24,836	24,544	9.658	5.912	24.93	26.82	2,152	650	5.85	46.28	92.94	3.79
L. S. & M. S.	......	......	......	......	......	......	......	......	6.40	......	87.17	......
	25,882	25,610	10.077	5.455	23.92	28.12	2,162	667	5.91	41.81	85.09	3.27
No. 555.	10,926	10,801	3.832	10.069	20.27	21.55	1,445	508	.88	78.42	91.06	8.04
2-8-0-C Type	21,545	21,300	7.556	8.324	20.03	21.27	1,332	592	3.19	64.18	94.16	6.64
M. C.	25,030	24,801	8.798	6.399	24.43	28.45	1,620	635	5.02	49.81	85.86	3.86
No. 929.	15,376	15,204	3.531	8.682	23.38	26.58	1,642	486	.91	66.82	87.95	5.51
2-10-2-C Type	31,877	30,603	7.107	7.119	24.04	26.60	1,932	574	3.68	54.69	90.48	4.51
A. T. & S. F.	20,034	19,808	4.6	8.319	21.84	24.65	1,737	497	1.63	63.55	88.61	5.65

PASSENGER LOCOMOTIVES—FOUR-CYLINDER BALANCED COMPOUND.

Locomotive.	Speed, miles per hour.	Rev. per min.	Cut off per cent. of stroke.	Steam pressure, Lbs.	Ind. horse power.	Dyna-mometer horse power	Dyna-mometer pull, Lbs.	Total moist coal per hr.	Total dry coal per hr. Lbs.	Dry coal per sq. ft. grate area per hour.
No. 2512.	19.14	80.	39.7	215.2	495.7	439.7	8,615	1013.1	1005.	30.09
4-4-2 Type.	38.26	160.	49.7	206.4	994.6	842.9	8,262	3067.3	3038.	91.
DeGlehn.	57.39	240.	34.2	217.5	802.3	653.1	4,268	2665.5	2641.	79.09
P. R. R.	66.96	280.	29.2	215.	682.5	510.1	2,857	2925.	2897.	86.77
No. 535.	18.79	80	53.	220.4	808.4	642.3	12,815	2077.	2058.	42.56
4-4-2 Type	37.55	160.	50.5	221.	1296.1	1114.4	11,119	3293.	3258.	67.36
Bald. comp.	56.38	240.	51.3	221.9	1621.5	1269.8	8,444	5753.5	5701.	117.87
A. T. & S. F.	65.77	280.	47.7	219.5	1459.7	898.	5,120	5162.7	5104.	105.52
No. 628.	18.57	80.	44.9	202.	480.5	446.4	9,016	1217.7	1206.	41.51
4-4-2 Type	37.13	160.	47.8	198.8	813.7	754.5	7,622	2704.6	2679	92.18
Hanover.	55.7	240.	46.4	187.	816.4	644.4	4,339	3559.6	3523.	121.3
Loco. Works.	65.05	280.27	35.8	204.2	688.4	593.7	3,422	2558.	2525.	86.88
No. 3000	18.76	80.	45.9	210.8	714.4	606.5	12,121	1766.	1749.	35.05
4-4-2 Type	37.52	160.	57.1	221.4	1490.5	1278.8	12,780	4932.	4880.	97.79
Cole comp.	56.29	240.	53.7	212.3	1641.4	1475.6	9,831	6768.7	6694.	134.15
N. Y. C. & H.	65.66	280.	38.2	220.2	1368.9	1188.5	6,788	3929.	3889.	77.94
	75.05	320.	41.	222.3	1335.7	1045.4	5,224	4976.	4928.	98.76

Locomotive.	Total water evap. per hr. Lbs.	Total dry steam per hr. Lbs.	Dry Steam per sq. ft. H. S. Lbs.	Dry steam per lb. of dry coal. Lbs.	Lbs. steam per I. H. P.	Lbs. steam per D. H. P.	Temp. of fire-box.	Temp. of smoke-box	Draft front of dia-phragm.*	Effic. of boiler	Machine effic. loco	Heat effic. loco
No. 2512.	9,742	9,634	3.627	9.589	18.6	20.96	1,737	507	.92	74.88	88.71	7.83
4-4-2 Type.	20,184	19,977	7.521	6.575	20.67	23.16	1,818	591	3.53	51.35	89.23	4.86
DeGlehn.	18,241	18,003	6.778	6.818	21.62	26.56	....	586	3.56	55.99	81.41	4.53
P. R. R.	19,373	19,115	7.196	6.598	27.05	36.19	2,044	581	3.27	51.48	74.74	3.06
No. 535.	17,279	17,047	5.874	8.28	20.56	25.88	1,882	560	2.62	64.5	79.46	5.41
4-4-2 Type	25,924	25,585	8.816	7.86	19.41	22.58	1,975	625	4.54	62.48	85.99	6.04
Bald. comp.	34,126	33,630	11.589	5.9	20.48	26.15	2,162	689	6.59	46.05	78.51	3.81
A. T. & S. F.	31,102	30,681	10.572	6.01	20.73	33.7	2,177	660	5.58	47.27	61.53	3.03
No. 628.	9,176	9,176	5.234	7.607	17.82	19.18	2,108	597	1.29	63.3	92.91	6.65
4-4-2 Type	15,193	15,193	8.667	5.673	17.86	19.26	2,253	707	2.94	47.33	92.76	4.97
Hanover.	15,804	15,804	9.015	4.485	18.8	23.81	2,048	757	3.7	39.55	78.94	3.32
Loco. Works.	15,244	15,244	8.697	6.039	21.29	24.69	2,043	676	3.5	50.73	86.24	4.14
No. 3000	15,494	15,313	5.104	8.756	20.47	24.11	1,938	536	1.95	69.	81.89	6.18
4-4-2 Type	33,754	32,561	10.853	6.673	21.57	25.14	2,111	672	6.29	53.05	88.8	4.55
Cole comp.	41,120	40,034	13.343	5.98	24.14	26.86	2,339	743	8.88	46.89	89.9	4.01
N. Y. C. & H.	31,561	30,791	10.263	7.918	22.19	25.55	2,259	675	6.51	62.11	86.83	5.23
	32,906	31,818	10.604	6.456	23.51	30.04	2,174	678	6.68	51.02	78.27	3.42

* Inches of water

Locomotive number	1499	734	585	929	2512	535	628	3000
Total weight, lbs.	194,200	181,300	189,000	285,740	164,000	201,500	133,350	200,000
Weight on drivers, lbs.	173,200	162,600	164,500	233,760	87,850	99,200	65,350	110,000
Tractive effort, lbs. (M. E. P.-80% B. P.)	39,773	33,616	31,838	63,612	16,700	19,245	13,789	20,590
Diameter of drivers, in.	56	63	63	56½	80	79	78	79
Diameter of cylinders, in.	22	21	23 & 35	19 & 32	14.2 & 23.7	15 & 25	14,16 & 22	15½ & 26
Stroke of cylinders, in.	28	30	32	32	25¼	26	23⅝	26
Steam pressure, lbs.	205	200	210	225	225	220	200	220
Diameter of boiler, in.	71	68⅜	70⅛	81.	60.	69	62¼	72¼
Number and diameter of flues	373-2	338-2	363-2	393-2¼	139-2¾	273-2¼	241-2	390-2
Length of flues, ft. and in.	13-8½	14-10⅞	15-10⅜	19-10½	14-8⅛	18-9⅛	12**	15-11¼
Flue heating surface, sq. ft. †	2677.27	2638.97	3015.34	4601.	1468.87	3016.71	1511.94	3255.27
Total heating surface, sq. ft. †	2843.67	2857.89	3181.03	4817.36	1646.15	3237.01	1932.16††	3406.96
Grate area, sq. ft.	49.2	33.76	49.42	58.41	33.39	48.36	29.06	49.9
Firebox H. S.÷total H. S. per cent.	5.9	7.7	5.2	4.5	10.8	6.8	5.5	4.45
Total H. S.÷grate area	58	84.7	64.4	82.5	49.4	67	66.5	68.3
Tractive eff. × diam. driv.÷total H. S.	783	742	630	745	810	470	558	478

†—Water side of tubes, calculations are based on area of fire side tubes. **—Not including 2 ft. 6 in. in Pielock superheater.
††—Includes superheating surface.

The above table is one which has been compiled for use in the office of this Journal and has proved to be so handy for ready reference that it is believed our friends will find it of convenience and value.

It contains the results obtained from the locomotives, tested on the testing plant of the Pennsylvania Railroad at the St. Louis World's Fair which are most often desired for reference, either for comparison with other tests or as a basis of design. The results included in the table are those from the tests which gave the highest indicated horse-power at each speed tested for each locomotive. It should be remembered that this is by no means the most economical point of operation and that these results simply show what the locomotives were capable of doing under the conditions imposed and do not necessarily indicate what it would be desired that they should do for economy of coal, water or repairs. Reference should be made to the complete figures of all the tests published by the Pennsylvania Railroad Company for information on that and many other similar points

CO-OPERATION BETWEEN THE OPERATING AND MECHANICAL DEPARTMENTS.

(Suggestions for Decreasing the Cost of Locomotive Repairs.)

BY A. W. WHEATLEY.

Many operating men would be surprised if they were to examine the annual statements of their roads and note the large amount of money expended in the maintenance of locomotives. Ordinarily they consider this a matter of minor interest and apparently overlook the effect of it on the cost of conducting transportation.

Considering the general usage of locomotives on the road: Apparently very little attention is given to the movement of the average freight train over a railroad. On a single track road doing a heavy business many cases of poor dispatching occur. The dispatchers are worked to their limit, and they are not infallible. Do they receive the same supervision in checking as the other departments do? The engineers make daily reports showing all delays and copies of these reports are sent to the superintendent and master mechanics, but are they examined with a view of improving conditions? These men are very busy and undoubtedly cannot look over all of these reports carefully. Would it not be better if only the worst reports were submitted to them, those, for instance, where trains exceed a certain time in going over a division? These daily reports are very important and represent the pulse of the railroad.

For comparative purposes reports should be prepared monthly, showing by divisions the total number of engine hours, the total available engine hours, the total actual engine hours, and the average speed per actual engine hour. Such a report would show exactly what is being done and would be valuable in many ways.

The chief train dispatcher can do a great deal toward reducing the cost of repairs by co-operating with the local mechanical officials. Systematic assistance from the dispatcher as to the probable engine requirements for a given period in advance will be of material benefit. Roundhouse foremen frequently know of work that should be done on a locomotive, but are unable to do it because of inability to secure reliable information as to when the engine will be wanted. The foreman is compelled to protect himself, as he is usually severely criticized if unable to furnish power when needed. It is not at all uncommon for locomotives to remain from six to ten hours in the roundhouse without having any work done on them, not because repairs are not necessary, but because the roundhouse foreman did not know when the engines would be called for. The old saying that "a stitch in time saves nine" has an important application to a locomotive; cylinder packing examined today will frequently prevent a failure tomorrow. Reports can and should be furnished to roundhouses at 9 A. M. and 6 P. M. for power that will be required during the ensuing ten hours.

Power is seriously affected by the improper handling at the terminals and many failures can be attributed to this cause. Master mechanics should give their personal attention to this matter. Hostlers permitting power to remain out of doors longer than necessary or abusing locomotives on the cinder pit by the improper use of blowers should be disciplined. Roundhouses should be designed to permit of the locomotives having the fire cleaned inside, instead of out of doors, thus permitting of their being housed promptly on arrival at the terminal. Suitable ventilation and conveyors should be provided and with such an arrangement the delay of locomotives at terminals could be materially reduced.

Ordinarily the roundhouse foreman pays very little attention to the cost of repairs. Some means should be provided by which he may be made familiar with these costs. The locomotives should be operated with an allowance for repairs, statements should be furnished showing the financial condition of each engine every two months; these reports should be posted in a conspicuous place in the roundhouse, so that the engineers may also become interested. The average engineer and mechanic is ignorant of the cost of power and maintenance and some means must be taken to place the figures before them and to set them thinking; at the same time it will show that the officers are interested in this matter and that it is one of importance. The system suggested above will encourage the roundhouse foreman to improve the efficiency of his organization.

The foreman should be allowed sufficient help to keep the power clean. Many roads have practically discontinued the cleaning of locomotives, but this would appear to be a serious mistake. Nothing is more demoralizing than dirty power. It tends to destroy the personal pride of all concerned. Put an engineer or a mechanic on a dirty locomotive and nine times out of ten you will get poor work in return.

The shopping of locomotives at the proper time is an important matter. Care should be taken that locomotives are not shopped until there is a vacancy in sight. With a road doing a reasonably even business, this is not a difficult matter. In this connection the writer feels that engines should be required to make certain fixed mileage between shoppings for general or heavy repairs. This will prevent the shopping of engines for expensive repairs when light roundhouse repairs are all that is necessary. Considerable money is wasted in this manner, especially at a time of transferring power from one division to another. The receiving master mechanic and superintendent, get together and scrutinize the power just received, and for some unexplained reason it is never as good as the power they have parted with, and they decide to shop it and put it in first-class condition, smiling with an assurance that the other fellow must pay for it.

Shop organization has received a great deal of attention recently, and it can be said without fear of contradiction that on many roads the railroad shop is the best supervised and the most economically managed department. The most important feature in the operation of a shop is that of cost and an allowance plan can be used to marked advantage. Job prices should be fixed; also a total repair price, and these costs should not be exceeded except for good reasons. In all branches of the work we should endeavor to give the man a mark to reach, one that can be reached at times by special effort, so that he will not become discouraged and consider it impossible to reach.

Very little can be accomplished without co-operation and harmony between the different departments. Unfortunately the average railroad man has very little regard for departments other than the one with which he is connected. The superintendent, if his title is correct, should be held absolutely responsible for every cent of expense in his territory. *The title of master mechanic should be replaced by that of assistant superintendent; this will have a tendency to broaden mechanical men and place them in line for higher positions.* Division superintendents should report to the superintendent of motive power on mechanical matters. With such an organization the different departments will be brought closer together and all concerned will become broader and better men. The railroads today are suffering from the lack of such men and its effect on the cost of locomotive repairs cannot be overestimated. The subject is a very serious one, and deserving of equal attention by both mechanical and operating officials.

INCREASING COST OF RAILROAD SUPPLIES.—An idea of the increasing cost of supplies which must be purchased by a railroad is obtained by comparing prices paid by the Pennsylvania Railroad Company last year (1906) with those of the current year. Steel angles have increased in price 31 per cent., bronze journal bearings 25 per cent., copper 22 per cent., freight car wheels 21 per cent., and malleable iron castings 20 per cent. Brass and tin have each increased 16 per cent., car axles and cross ties 12 per cent., rail braces 8 per cent., white pine lumber 8 per cent., and air brake hose 7 per cent.

PROGRESS ON THE PANAMA CANAL.—The Isthmian Canal Commission announces that the excavation on the canal during July was as follows: Culebra division, 770,570 cu. yds.; Gatun, 74,765 cu. yds.; dredging in canal prism, 212,710 cu. yds.; total, 1,058,771 cu. yds., against 780,957 cu. yds. in June. This is the largest month's work yet done. The rainfall for the month is reported at 9.5 in., against 14 in. in June.

FORGING AT THE COLLINWOOD SHOPS.

Lake Shore & Michigan Southern Railway.

(Editor's Note: Other articles describing the machine forging work done at the Collinwood shops will be found on page 142 of the April, 1906, issue; page 234, June, 1906; and page 192, May, 1907. Similar work which is being done at the South Louisville shops of the Louisville & Nashville Railroad was described on page 125 of the April, 1907, issue.)

The dies and header for welding the end or cross bar on an ordinary clinker hook are shown in Fig. 1. Both bars are heated to a welding heat and placed in position between the dies; at one stroke of the machine they are welded together and the stock is gathered at the intersection to strengthen it, as shown in the illustration. To guard against the loss of welding heat when the comparatively light bars come in contact with the heavy dies a jet of compressed air* is blown on them. Those of our readers who have tried the experiment of burning a bar of iron by heating and then playing a jet of compressed air upon it will understand this action. After the two bars are welded together the hook is completed by bending it on a device attached to the forging machine.

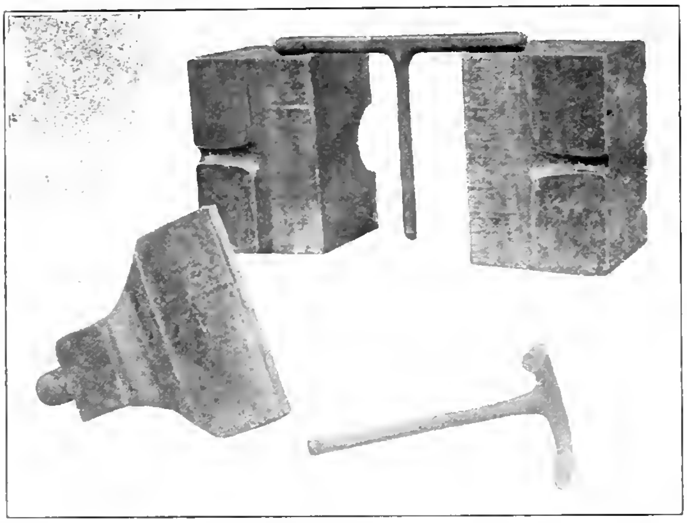


FIG. 1. DIES AND HEADER FOR WELDING END ON CLINKER HOOK.

FIG. 2. DIES AND HEADER FOR FORGING SLING STAY I-BOLT.

The dies and headers for making sling stay I-bolts at one operation on a 3½ in. Ajax forging machine are shown in Fig. 2. The end of the bar is first pinched in the dies so that it will enter the hole in the end of the header. The bar is then brought up against a stop which adjusts the length and the dies are closed, shearing off the end and holding the blank in the pocket of the die; the header then comes forward and forms the pin and collar.

The dies and headers shown in Fig. 3 are used for forming and punching brake hangers made of 7/8 in. round iron. Those shown in the upper half of the photo upset the ends and form the boss, and those in the lower half punch the hole through it.

The device shown in Fig. 4 is used in connection with a bull-dozer for bending and shearing a steel ratchet pawl at one stroke of the machine. The blank is first punched out on the forging machine; it is then heated and flattened under a Bradley hammer, after which it is quickly passed to the operator of the bull-dozer, before it has had time to cool, and is pressed to shape and sheared. The two wedges are fastened to the face plate or plunger of the bull-dozer and the rest of the device is clamped to the table. As the plunger of the bull-dozer moves forward the long wedge enters the device and forces the dies together, bending and gripping the pawl; the short wedge on the left then enters and forces the shears forward, cutting off and completing the pawl.

A combination tool for bending drawbar pockets and punching a hole for liners is shown in Fig. 5. After the bar for the pocket has been gibbed and sheared to the proper length on the forging machine it is heated and clamped in the head of the device by means of the lever which operates a cam. When the head moves forward the iron comes in contact with the two rollers and is bent to shape. These rollers may be adjusted for different widths of couplers by placing liners behind the frames in which they are carried. At the same time that the bar is being bent to shape the hole for the liner is punched.

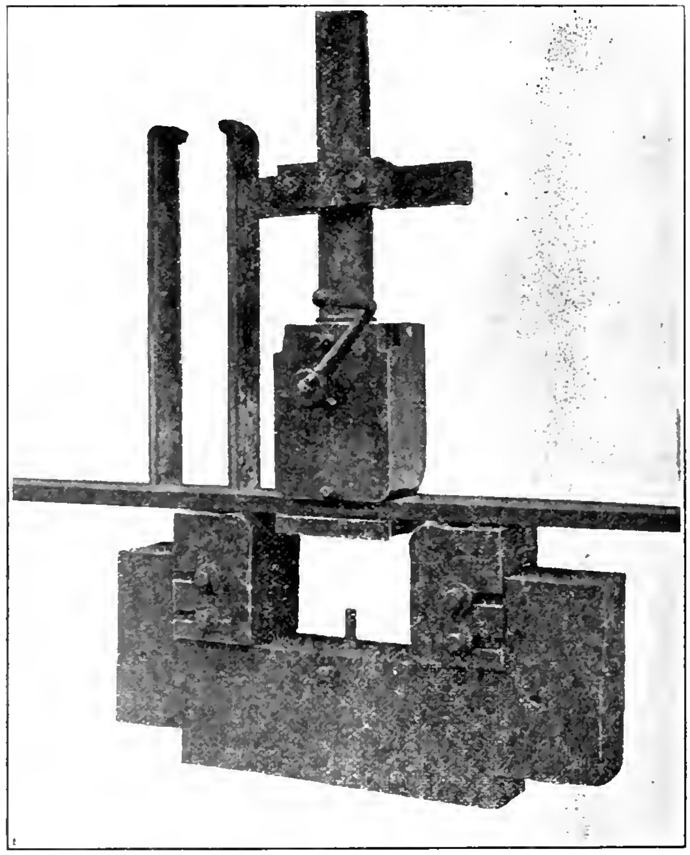


FIG. 5. COMBINATION TOOL FOR BENDING AND PUNCHING DRAWBAR POCKETS.

* See following article.

COMPRESSED AIR IN FORGING.*

One of the small kinks in the Collinwood shops that has helped us in successful welding in the forging machine, is a compressed air jet used for bringing two pieces of iron to a point of fusion immediately before the stroke of the forging machine.

While some blacksmiths may be familiar with this method, we find it is new with many others. A very interesting experiment to demonstrate the possibilities with this method is to heat a bar of one inch or one and one-fourth inch iron on the end for five or six inches, then blow a stream of air against the end of the bar parallel with its length; a beautiful display of fire-

* Note connection with previous article.

works will be the result, the temperature of the bar will be raised to a point of fusion and the bar will melt away as in the foundry cupola.

We have been quite successful in making large crank pin nuts with the aid of this method. A piece of bar iron 2 x 7/8 in. is rounded up under the hammer, each end of the bar being sheared to an angle of 45 degrees so as to form a lap. These pieces of iron are heated in an oil furnace, placed between the dies of the forging machine, a jet of air is blown against the two ends, which cleans out all dirt and scale and raises the temperature of the metal to a welding heat, one stroke of the machine insuring a perfect weld with clean metal.

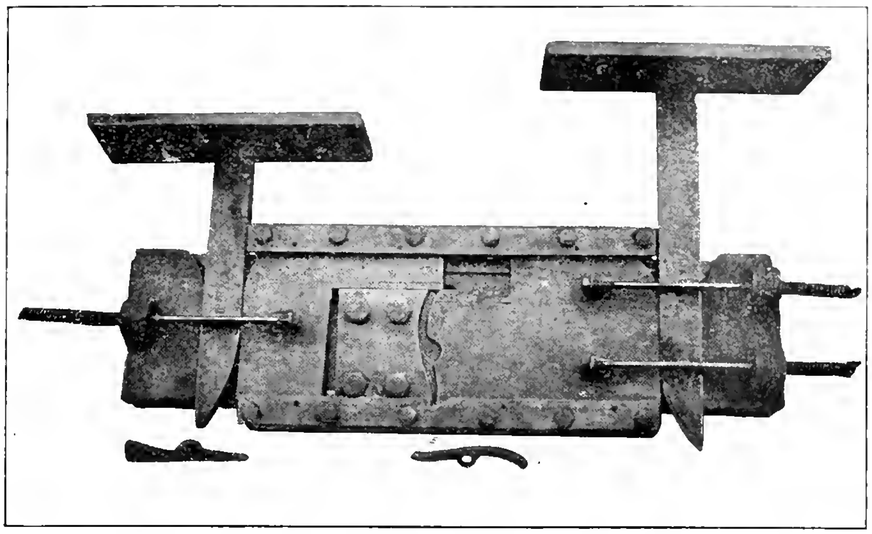


FIG. 4. DEVICE FOR BENDING AND PUNCHING STEEL RATCHET PAWLS.

The same method is used in welding the cross bar on our clinker hooks for locomotive service. The end of the long rod and a short bar are both heated to a welding heat in our oil furnace; the long rod is butted against the short piece and placed between the dies, where it comes in contact with the jet of compressed air, which blows out all scale and dirt, bringing the two pieces to a perfect welding heat and one stroke of the machine completes the weld and upsets the metal so as to strengthen the hook at the point of intersection.

In repairing and welding broken spokes or rims in steel driving wheels, we think the compressed air jet is indispensable. Some of the wheels are very difficult to handle owing to the counterbalance and it is very difficult to get a wheel from the fire to the anvil without losing the heat. By using the compressed air jet it is possible to revive the heat and the parts to be welded will retain a welding heat after the operation is completed. In welding spokes in steel wheels we use the "V" weld. The heat is taken on a side fire and just before the piece is welded into the spoke, the compressed air jet is brought in contact with the hot metal, keeping the temperature of the metal up to a welding heat until the operation is completed. Care must be taken, however, in applying this compressed air jet, as it would be possible to burn a spoke in two if held at one point too long.—*Mr. Geo. A. Hartline, Blacksmith Foreman, L. S. & M. S. Ry., in the Railway Journal.*

Long Island Passenger Traffic.—The average daily passenger traffic on the Long Island Railroad amounts to about 60,000, there being about 40,000 carried per day in winter and 80,000 in summer. On last Decoration Day there were 128,625 passengers carried on this system.

THE SURCHARGE PROBLEM.

The cost of material manufactured on the road, as listed on store house books, is usually low compared with market prices. The value of manufactured material is commonly figured as direct labor cost plus material cost, and I find some roads adding from two to ten per cent. to their labor to cover handling and other direct expenses. These figures are ridiculously low, as manufacturers find that overhead or surcharge expenses are often two and three times the direct labor. It is not important that cost be figured accurately when the material is only passed from one department of a road to another, or from one division to another. It is in this case simply taking from one pocket and putting in another.

It is important that values be known accurately when the question arises of buying or making certain articles. All the cost of rent, supervision, machinery, power, heat, light, etc., enters into the cost of each repaired engine, or engine part, delivered from the locomotive repair shop. Until these items are all prorated over the cost of the shop output no comparative figures as to value are obtained.

These items make up the surcharge problem and are just as real a part of the cost as the material or the labor which we call direct, and locate. Direct labor and unlocated cost each enter into the final value of an article just as much as power to move a balanced compound engine is developed in both the high pressure and low pressure cylinders. The high pressure cylinders may be between the frame and not in evidence to the untrained eye, but these cylinders must be considered in figuring tractive effort or we underestimate it in about the same proportion as we underestimate costs if we do not include the surcharge, which is no more evident to the untrained mind than the high pressure cylinders of a balanced compound are to a farmer.—*Mr. H. W. Jacobs.—From a paper read before the Railway Storekeepers' Association.*

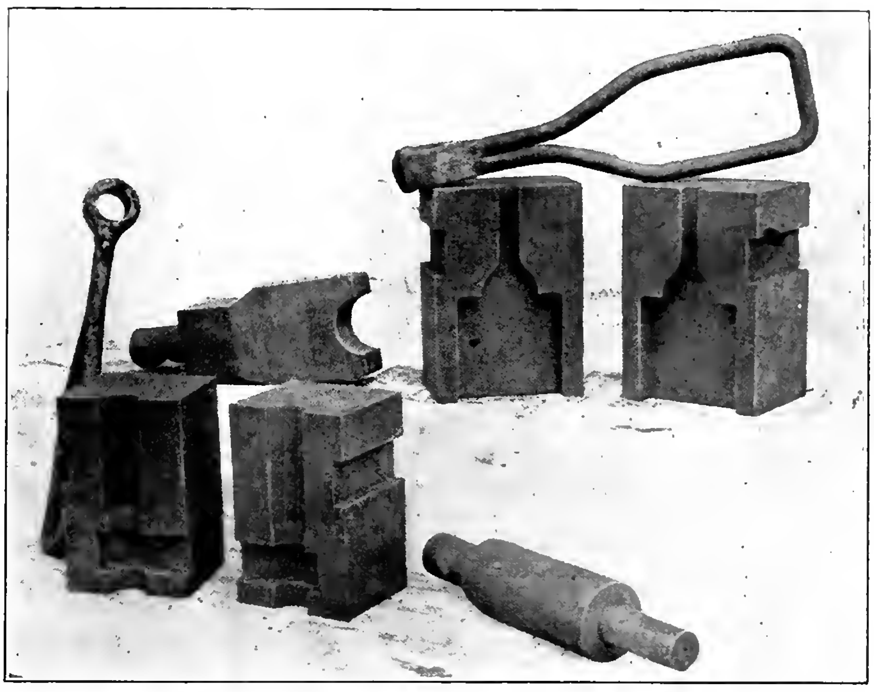
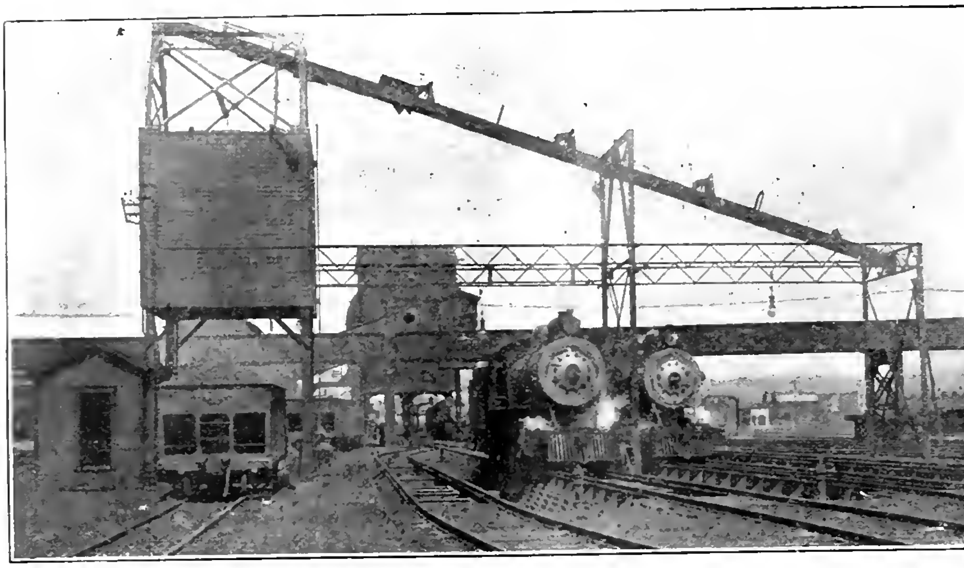


FIG. 3. DIES AND HEADERS FOR FORMING AND PUNCHING END OF BRAKE HANGERS.

Master Car and Locomotive Painters' Association.—This association will hold its annual convention at the Ryan Hotel, St. Paul, Minn., on September 10th.



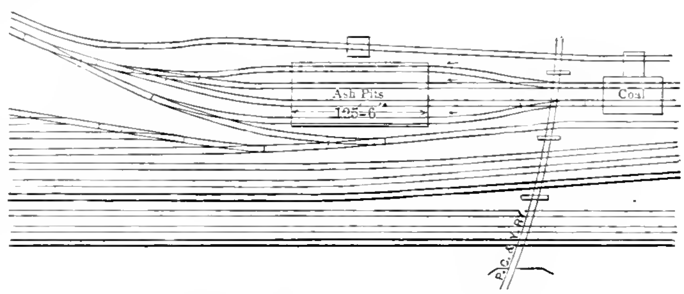
ASH HANDLING PLANT—PITTSBURGH & LAKE ERIE RAILROAD

ASH HANDLING PLANT.

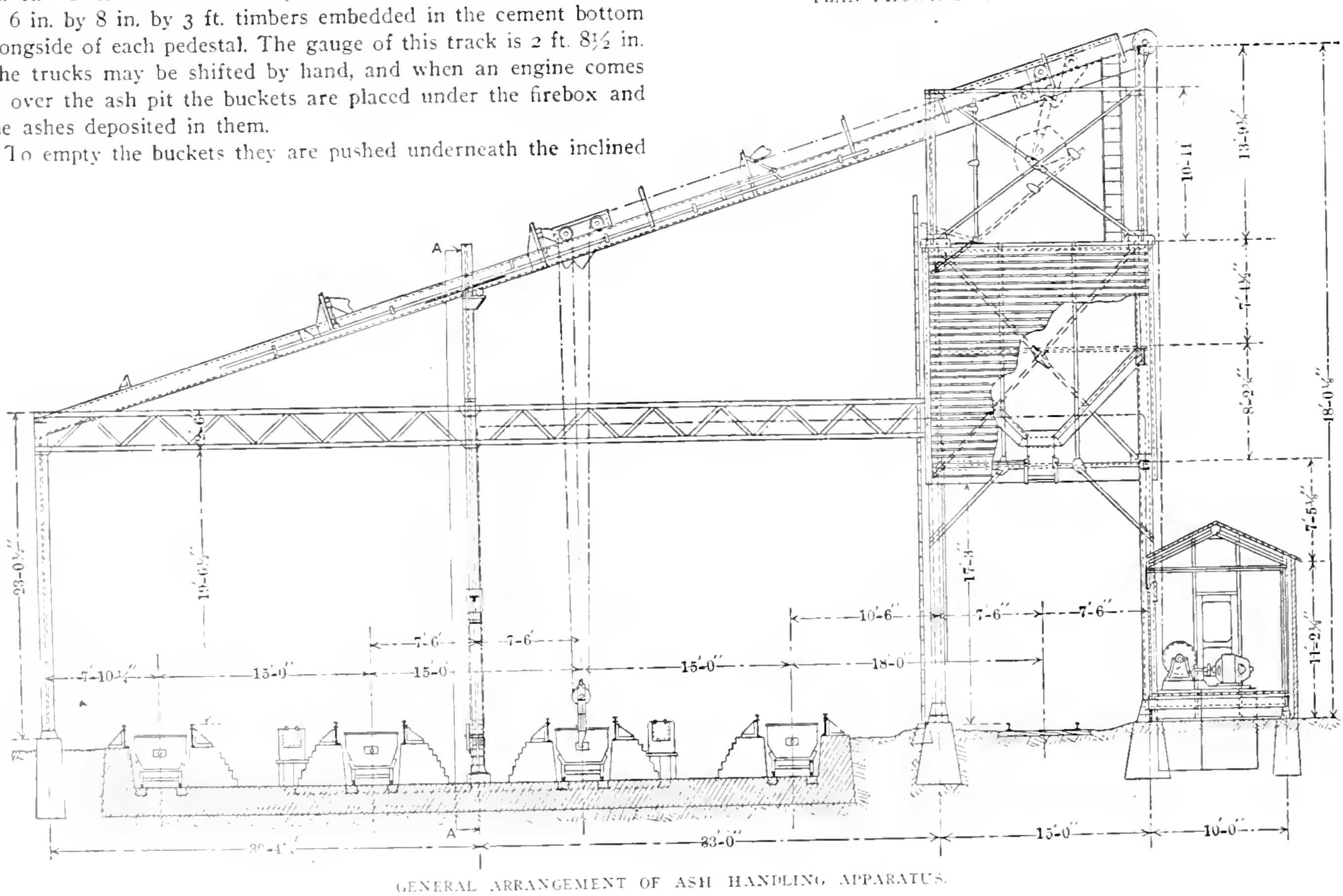
Pittsburgh & Lake Erie Railroad.

For the past two years the Pittsburgh & Lake Erie Railroad has had in operation, at McKees Rocks, an ash handling plant which is radically different from the type ordinarily used and has given very satisfactory service. As may be seen from the plan each track under the coaling station connects with two ash pit tracks. The four ash pit tracks are each about 122½ ft. long, and extend over what is practically one large pit. The bottom of the pit is of concrete, 2 ft. thick, and is carefully designed so that it will drain off quickly. The 80-lb. track rails are supported on 15-in. I beams, carried on vitrified brick pedestals, spaced 5 ft., center to center. On each ash pit track are 6 buckets, each having a capacity when loaded level of 45 cu. ft. These rest on trucks, which run on 20-lb. rails spiked to 6 in. by 8 in. by 3 ft. timbers embedded in the cement bottom alongside of each pedestal. The gauge of this track is 2 ft. 8½ in. The trucks may be shifted by hand, and when an engine comes in over the ash pit the buckets are placed under the firebox and the ashes deposited in them.

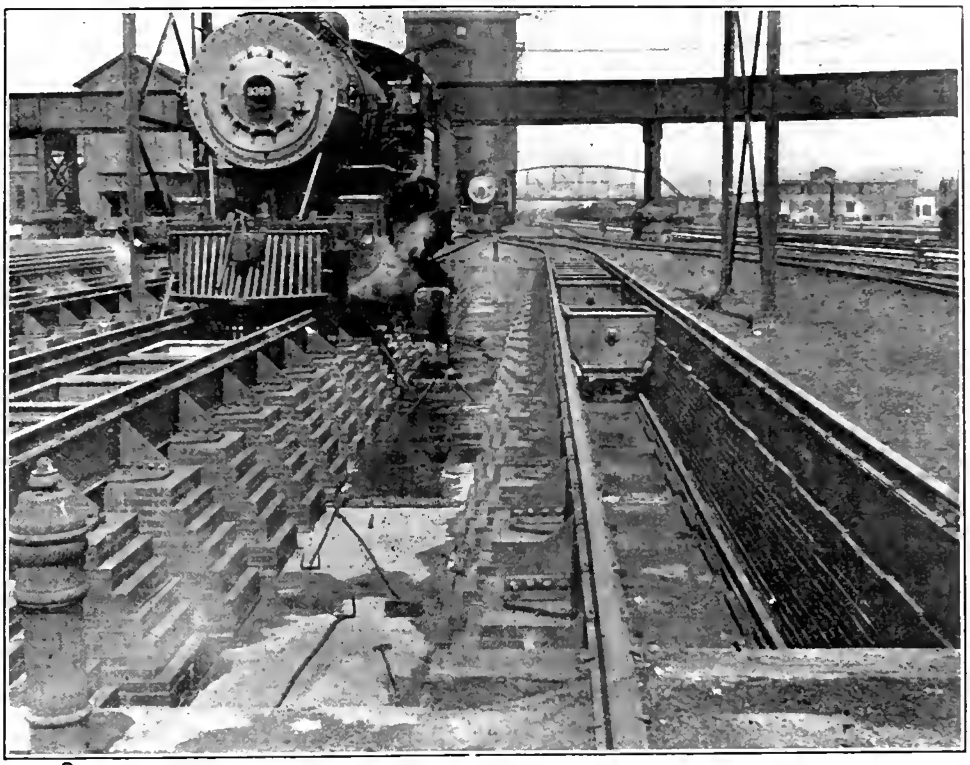
To empty the buckets they are pushed underneath the inclined runway, which spans the four tracks and passes over the ash bin at its upper end. The buckets are raised and conveyed to the bin and dumped by a hoist and a trolley on the run-way, operated by a winding drum driven by a 15 horse-power Crocker Wheeler motor in the small house on the ground beside the ash



PLAN SHOWING LOCATION OF ASH PITS.



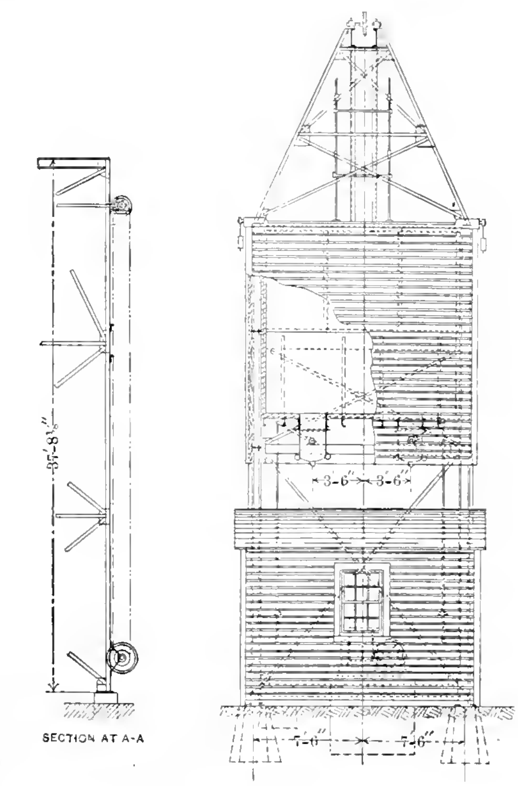
GENERAL ARRANGEMENT OF ASH HANDLING APPARATUS.



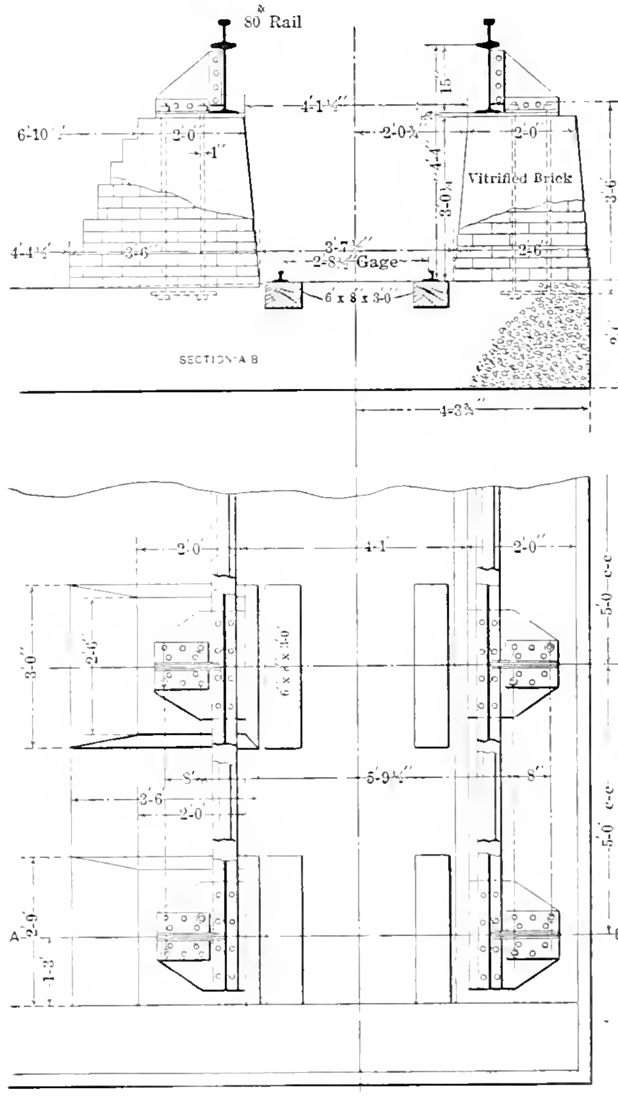
VIEW OF ONE SECTION OF THE ASH PITS.

bin. The motor is governed by two controllers, one between the first and second tracks and the other between the third and fourth tracks, as shown in the illustrations. The trolley may be made to stop at will over any track by manipulating the large hand wheel at the side of the middle column, which through a gear driven chain and a set of bevel gears on the run-way operates a rack, the position of this rack determining the point at which the trolley will stop on its return from the ash bin. The hoist has two hooks which slip over pins at each end of the bucket. After the bucket starts to rise the operations, until it is dumped, are automatic.

The ash bin has a capacity of 35 tons and is lined with expanded metal and concrete. The ashes are loaded from the bin

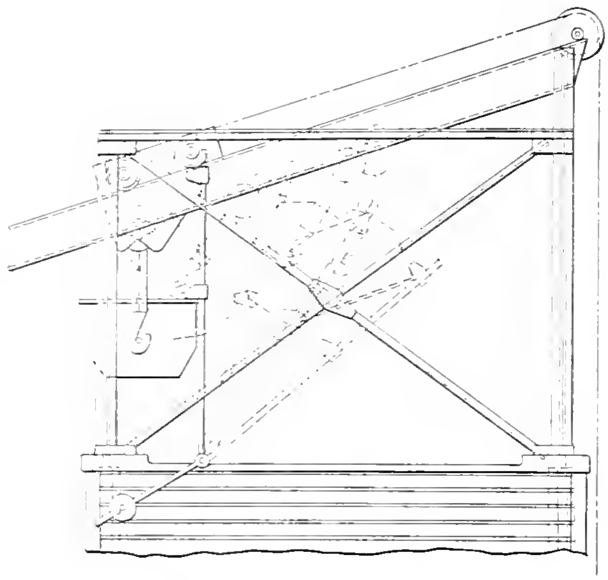


SECTION AND END VIEW OF PLANT.



DETAILS OF ASH PIT CONSTRUCTION

directly into steel hopper cars, the tracks upon which these cars run being a continuation of the coal supply track, so that when a coal car has been unloaded it may, if desired, be shifted to the ash bin. The coaling plant and the ash handling plant are operated by one man, it being only necessary for him to empty the



METHOD OF EMPTYING THE BUCKETS.

ash buckets after a number of them have been filled. As the ashes are dumped directly into the buckets and the remainder of the operations are performed by machinery and gravity, the amount of labor required is greatly reduced, and the ashes do not have an opportunity of freezing during the winter. This apparatus was designed and installed by Heyl & Patterson, Inc., of Pittsburgh.

GOVERNMENT OWNERSHIP OF RAILWAYS.—I am opposed to government ownership—

First, because existing government railroads are not managed with either the efficiency or economy of privately managed roads and the rates charged are not as low and therefore not as beneficial to the public.

Second, because it would involve an expenditure of certainly twelve billions of dollars to acquire the interstate railroads and the creation of an enormous national debt.

Third, because it would place in the hands of a reckless executive a power of control over business and politics that the imagination can hardly conceive and would expose our popular institutions to danger.

The supervision proposed need not materially reduce the legitimate operation of individualism in railroad enterprise. It will indeed limit the opportunity to accumulate enormous fortunes through overcapitalization or secret rebates, but the legitimate profit which comes from close attention to operation, to efficiency of service and economy in details and from broad conceptions of new methods of reducing cost without impairing the service will not be disturbed in the slightest.—*From Secretary Taft's Columbus Speech.*

CO-OPERATION.—Not only do we need greater co-operation between the railways and the general public, but we need greater co-operation within the railways themselves. The time was when the general manager was, to use a slang expression, "the whole thing." He carried his office under his hat; he knew every shipper on the road, and every employee. That day has gone by, and we have come to a highly specialized and highly differentiated organization where the "right hand frequently does not know what the left hand is doing." For that reason, I preach co-operation every time I have a chance, for surely the best results can only be obtained when every department of the railroad works in harmony and co-ordination with every other.—*Mr. F. A. Delano, President of the Wabash Railroad, before the Traffic Club of Chicago.*

SERVICE TEST OF HIGH SPEED TOOL STEELS.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

A comparative test of tool steels, to be of any value to the average railroad shop, must be made under service conditions and extend over a considerable period of time, so as to take into consideration the effect of breakage and redressing and to average the conditions under which the cutting is done. One tool steel representative will present an argument to the effect that although his steel is more expensive than some others, yet in the long run it is the most economical. Another will argue that his steel is cheaper, and although it may be a little more brittle or wear faster, yet when everything is taken into consideration it will prove the least expensive. Ordinarily the shop managers are accustomed to judge the merits of the various steels by working them to the limit of their capacity under a short test, but this gives no basis for determining the final result under service conditions.

At the Collinwood shops of the Lake Shore & Michigan Southern Railway a series of records have been kept, extending over a year or more, which, although they required only a very small expenditure of time on the part of those interested, contain data from which it is possible to calculate accurately the efficiency of the various makes of steel which were used. No attempt has been made to keep a record of tools other than those used on the tire turning lathes, as the greater part of the high speed tool steel is purchased for that purpose and after the tire turning tools have become too small they are worked up into smaller tools for the other machines.

The method of keeping the records is as follows: All brands of high speed steel for use on the wheel lathes are stamped with

SERVICE TEST OF HIGH SPEED STEELS.

January 1 to July 1, 1906.

MAKE OF STEEL	A	B	C	D	D
Size of tool ins.	1½x2½	1½x2½	1½x2½	1½x2½	1½x3
Lbs. of metal removed	4255.06	17003.23	3228.88	29423.19	27160.11
Times re-tempered	3	3	2	7	1
Times dressed due to wear	7	4	2	14	18
Times dressed due to breakage	1	3	1	28	14
Total number of dressings	11	10	5	49	33
Lbs. of metal removed per dressing	386.82	1700.32	645.77	600.47	823.03
Lbs. tool steel used per dressing	2.25	3.428	2.25	2.43	3.58
Cost of tool steel per 100 lbs. metal removed (cents)	32.	11.2	23.	26.7	28.7
Efficiency*	17.1	49.6	28.7	24.7	23.0

*Assuming 1000 lbs. of tire steel removed per lb. of tool steel equal to 100 per cent.

a letter or sign to designate the make and a number is given to each tool so that an individual record may be kept of it. The tool grinder makes note of every time the tool is brought to him for grinding and at the same time records, from information which has been chalked on the tool by the machine operator, the number of tires that have been turned by it since the last dressing and the size of each tire; also whether the cause of regrinding is due to wear or to breakage and whether it has been retempered. The weight of the tool before and after dressing is also noted. In a test of this kind it would, of course, not be feasible to weigh the cuttings from each tire, or part of tire, turned by each tool, but the amount of metal removed is based on the results of a careful investigation from which the average amount of metal removed for each different size of tire was determined. As the average amount removed from a tire 80 in. in diameter is less than 200 lbs., and from a 61 in. tire only about 150 lbs., it will readily be seen that a sufficient number of tires were turned by most of the different steels tested, so that the use of average figures should give fairly accurate results.

The accompanying tables show the results of the tests for two periods, one for the first six months of 1906 and the other for the last six months. The different makes of tool steel are designated by the letters of the alphabet. The tools were all ground to a uniform size and shape on a Sellers tool grinder. Data was kept for roughing tools only, the diamond point clearance angles being: Front or end clearance, 9 degs.; top rake, back, 10 degs.;

top rake, side, o degs.; side rake, o degs. The size of the tools for the first test was the same in all cases except that steel D was tested in two sizes. During the latter part of the year the tools were all of the larger size, $1\frac{1}{2}$ x 3 in., except steel A which was tested in the smaller size only.

The larger size tools show a considerably higher efficiency, due to the reduction of breakages, and while the amount of tool steel used per dressing is increased with the larger size, the pounds of metal removed per dressing is greater in proportion except in the case of steel B. Steels A and C were hardly used extensively enough during the first six months to insure accurate results with the use of average figures for the amount of metal removed, but the other makes and all of those tested during the second period, were used on a large enough number of tires to insure a fair degree of accuracy.

For the $1\frac{1}{2}$ x $2\frac{1}{2}$ in. size tools steel B has by far the best record. Comparison of the results for the two sizes of steel D for the first six months would indicate that there was no advantage in using the larger size steel, except that the number of breakages was reduced, although the greater amount of tool steel used per dressing more than offset this. As the cost of tool steel per 100 lbs. of metal used, as shown in the tables, is based on the first cost of the tool steel only, and does not consider the actual cost of redressing and retempering, the larger size tool would probably prove more economical in this case because of the smaller number of breakages. It would be a simple matter to include the cost of redressing in the figures upon which the efficiency is based. Except in this one instance a comparison of the results of the two sizes of tools shows a considerable advantage in favor of the larger size.

During the last half of the year the larger size tools were tested. Steels C and E are about evenly matched and gave

SERVICE TEST OF HIGH SPEED STEELS.

July 1, 1906, to January 1, 1907

MAKE OF STEEL	A	B	C	D	E
Size of tool, ins.	$1\frac{1}{2}$x$2\frac{1}{2}$	$1\frac{1}{2}$x3	$1\frac{1}{2}$x3	$1\frac{1}{2}$x3	$1\frac{1}{2}$x3
Lbs. of metal removed	13891.78	92932.114	53037.93	49751.67	22297.85
Times re-tempered	6	22	11	29	5
Times dressed due to wear	9	27	18	17	8
Times dressed due to breakage	0	6	2	15	0
Total number of dressings	15	55	31	61	13
Lbs. of metal removed per dressing	926.1	1689.7	1710.9	815.6	1715.2
Lbs. tool steel used per dressing	4.4	3.6	2.3	4.4	2.15
Cost of tool steel per 100 lbs. metal removed (cents)	26.2	11.7	8.9	35.6	52.2
Efficiency*	21.	47.	74.5	18.5	79.7

*Assuming 1000 lbs. of tire steel removed per lb. of tool steel to equal 100 per cent.

very much better results than any of the other makes, steel E having some slight advantage over C, apparently largely due to the fact that steel C suffered from breakages. Steel B made a very good record as far as the pounds of material removed per dressing is concerned, but the pounds of tool steel used per dressing was very much greater than for C and E.

With a record of this kind, the keeping of which entails practically no expense, but serves to interest the workmen in the output, the shop manager has an accurate and definite basis upon which to draw conclusions as to the make of steel which will do the best work with the greatest degree of economy.

TRADE BETWEEN UNITED STATES AND LATIN AMERICA.—During the year ending June 30, 1907, the value of the imports from Latin America to United States amounted to $360,000,000; the exports from United States to Latin America amounted to $250,000,000.

CANADA'S POPULATION.—Figures compiled by the Census and Statistics Department of the Canadian Government show that the population on April 1, 1907, was 6,504,900, representing an increase of 1,133,586, or more than 21 per cent., in six years.

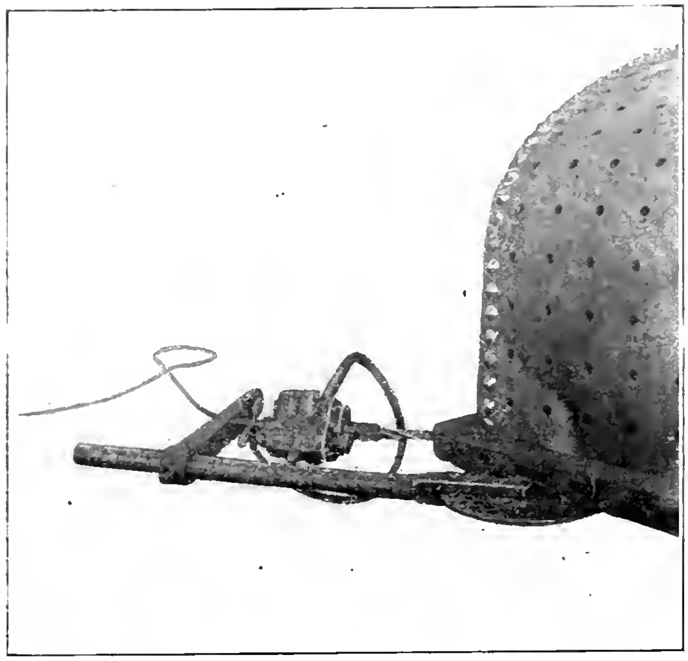
THE TRAVELING ENGINEERS' ASSOCIATION.—This association will hold its fifteenth annual meeting at Chicago on September 3, 4, 5 and 6.

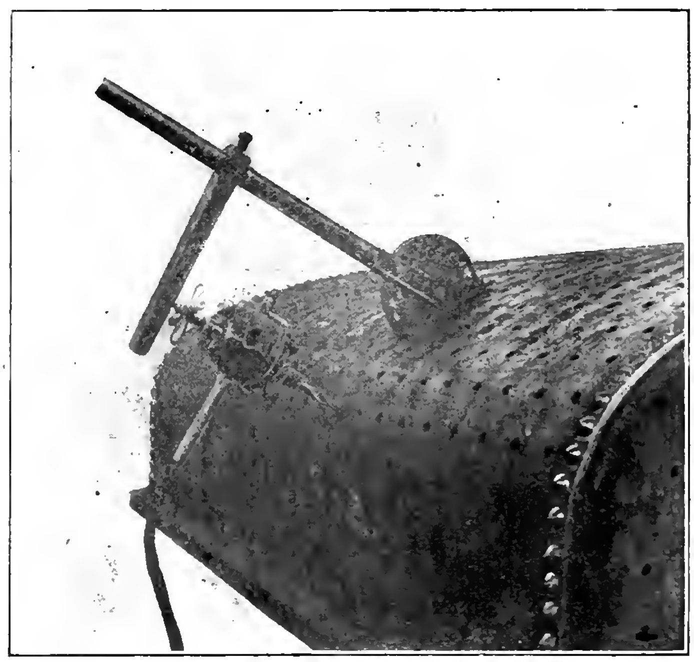
A HANDY DRILL POST.

BY F. G. DE SAUSSURE

The difficulties attending the satisfactory fastening and adjustment of a drill post or "old man" for work on curved surfaces, such as boiler shells and fire-boxes, are well known to all shop mechanics. There have been many temporary makeshifts fixed up to overcome the trouble in special cases which were thrown away as soon as they had answered their purpose, and it was up to the next man to conjure up something for himself.

For correcting this state of affairs at the Hornell shops of





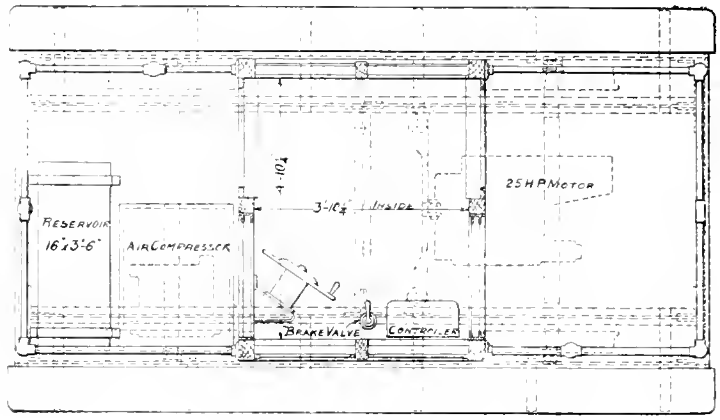
A HANDY DRILL POST.

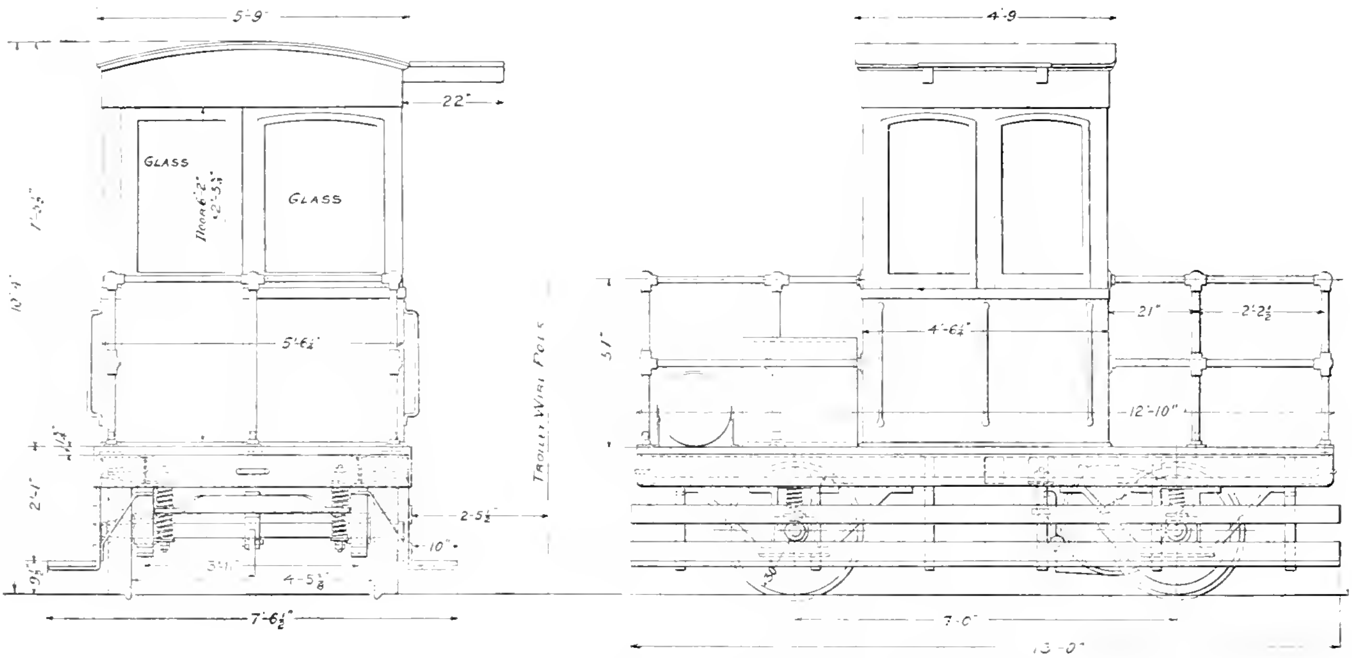
the Erie Railroad, Mr. Thomas Kuhn, foreman boilermaker, has designed and patented a device which while answering all the purposes of the rigid foot drill post is also available for convenient adjustment on curved surfaces.

As will be seen in the illustrations, the only material difference in this device from the usual drill post is in the construction and method of securing the base. The base here consists of a semi-circular piece of boiler plate $\frac{1}{2}$-in. thick, flanged so as

to leave a 3-in. right-angle turn and a full half circular base. In the center of this base a 3/4-in. hole is drilled and 1 3/8 in. from the circumference a series of equally spaced holes are also drilled. The right-angle flange is provided with 3/4 x 2 5/8-in. slots located 7/8 in. from each end, and through these slots pass the bolts that are to secure the device to its support.

The standard is of forged soft steel drawn square 10 in. from the end, and in this square portion a slot 5/8 x 6 1/2 in. is cut and two holes 3/4 in. diameter and 3 7/8 in. apart, drilled at right angles to the slot, permit pins to be dropped through the standard and base, the back pin acting as a pivot. By placing the standard at any angle with the base and dropping the forward pin into one of the holes along the circumference, any desired adjustment may be obtained.





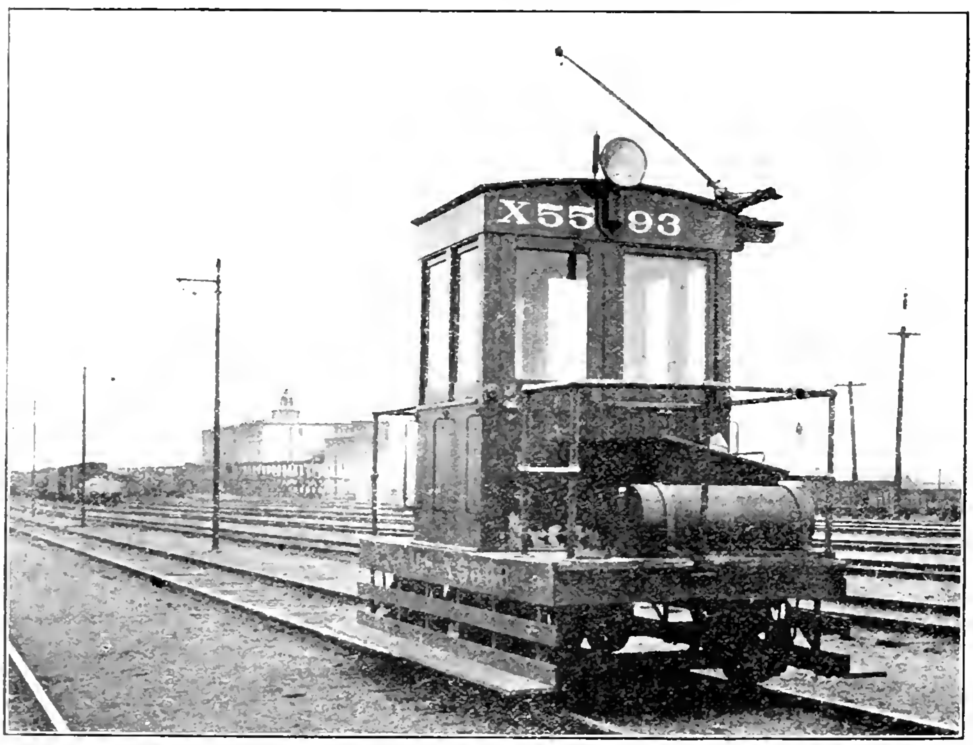
ELECTRIC CAR FOR HUMP YARD—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

ELECTRIC CAR FOR HUMP YARDS.

In connection with the operation of large hump or gravity yards it is necessary to provide some means for quickly transporting the switchmen from the place where they leave the cars back to the hump. A light electric car has been constructed at the Collinwood shops of the Lake Superior & Michigan Southern Railway for use in the yards at that place. The distance from the end of the yard to the hump, 1,750 ft., is traversed in about 60 seconds. A gasoline motor car was used formerly, but did not give satisfaction.

Electric current is transmitted from the power house at the repair shops, about one mile distant. The general construction of the transmission line is shown in the photograph. The current is furnished by a 40 kw. Crocker-Wheeler motor generator set, size 35-D, the primary side of which is wound for 250 and the secondary for 550 volts. It operates at a speed of 1,150 r. p. m. The set is large enough for two cars, although at the present time it is furnishing power for only one.

The car is of simple and light construction. The end sills are

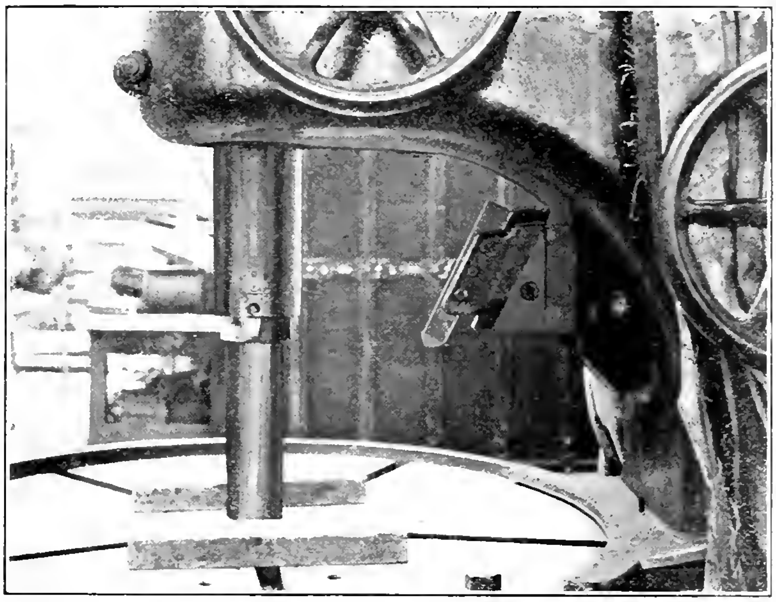


ELECTRIC CAR FOR HUMP YARDS.

7 in., $9\frac{3}{4}$ lb., channels and the two longitudinal sills 7 in., 15 lb., I-beams. The connection of the side plate to the floor timbers is reinforced by an angle iron. Thirty-inch steel tired wheels are used and the axles are fitted with Timken roller bearings. A 25 h.p. No. 131 Westinghouse mining motor drives the axle through gearing. A Westinghouse motor-driven air compressor, type SM-1, is used in connection with the air brakes and has a capacity for 15 cu. ft. per minute. The compressed air reservoir is 10 in. in diameter and 3 ft. 6 in. in length. An electric heater in the cab was furnished by the Simplex Electric Heating Company of Boston.

BORING MILL FOR DRIVING BOXES.

A Putnam car wheel boring machine at the Collinwood shops of the Lake Shore & Michigan Southern Railway has recently been changed to adapt it for boring and facing driving boxes. It has been equipped with a new boring bar which extends down through the table. The table has been bored out and fitted with a bronze sleeve to guide the bar. The cutting tool is held in place by a sliding wedge and the tool holder is adjusted by means of a screw. The horizontal head, which was formerly used for facing the hubs of wheels, was found to be too low for a 12 in. driving box. This was overcome by making a new sliding ram



BORING MILL FOR DRIVING BOXES.

with the head offset enough to take in the deepest driving box. The tool is carried in a head, which may be adjusted by a screw. A guard or shield has been placed around the edge of the table to prevent the clothes of the operator being caught by it. Canvas curtains are arranged so that the machine may be encased when it is operating and thus prevent the chips from being spread broadcast over the floor. The table revolves at the rate of 44 r. p. m. with a minimum speed of $4\frac{1}{2}$ r. p. m. and is driven by a 10 h.p. motor. Three vertical feeds are provided, $7\frac{1}{2}$, $4\frac{3}{4}$, and $3\frac{1}{2}$ in. per minute. The maximum horizontal feed is at the rate of $3\frac{3}{4}$ in. per minute and the minimum $1\frac{3}{4}$ in. per minute.

RAILWAY STATISTICS.

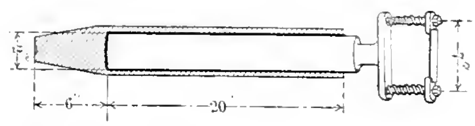
During 1905 there came about no change in the order of leading countries with regard to the length of their respective railway systems. After the United States, with its total of 219,800 miles, there follow the German Empire with 35,300 miles, European Russia with 34,360 miles, France with 29,042, British India with 18,778 miles, Austria Hungary with 23,039 miles, Great Britain and Ireland with 22,780, Canada with 20,717, the Argentine Republic with 12,482 miles, Mexico with 12,300 miles, Brazil with 10,503 miles, Italy with 10,180 miles, Spain with 10,180 miles, and Sweden with 7,928 miles. The other countries, which are not mentioned, possess less than 6,250 miles each.

With regard to the railway mileage as compared with the superficial area, Belgium still heads the list of countries, it $62\frac{1}{2}$ square miles be taken as the unit of comparison. Thus, Belgium has for every $62\frac{1}{2}$ square miles 15.4 of railroad track, Saxony has 12.4 miles, Baden has 15.2 miles, Alsace-Lorraine have 15.2 miles, Great Britain and Ireland have $12\frac{1}{2}$ miles, the German Empire has $6\frac{1}{2}$ miles, Switzerland has $6\frac{1}{2}$ miles, Würtemberg has 6.4, Bavaria has 6.2, and Prussia has 6.1 miles. In the case of the other continents the comparison is at a much lower rate; in the United States it falls to only 2.4 miles, but in 1904 it had 2.75 miles, because the returns for 1905 include Alaska, with its huge area and comparatively small railway system; without reckoning Alaska the proportion for the United States was 2.8 miles. In the other countries the proportion comes out only at a fraction of a mile.

With regard to population, taking 10,000 people as the unit, the Colony of Queensland comes first with 66.2 miles per 10,000 inhabitants. In the other Australian Colonies the proportion is very favorable, owing to the sparse population; the United States have 18 miles; in Europe, Sweden heads the list with 15.4 miles; and then follow France, with 7.44 miles; Belgium, with 6.54 miles; Germany, with 6.25; and Great Britain, with 5.5 miles.—*The Engineer (London)*.

HOLDING ON BAR.

An interesting holding on bar for rivets up to ½ in. is in use in the McKees Rocks boiler shop of the Pittsburgh & Lake Erie Railroad, and is shown in the illustration. The springs not only relieve the shocks and make it easier for the man, but it is possible to drive the rivets faster, since the bar returns more quickly to the head of the rivet when the shock jars it. It is also



HOLDING ON BAR.

possible to drive a better head with this bar. Under a test twelve ⅜-in. rivets have been driven in a minute; twelve hundred ⅜-in. rivets can be driven in 10 hours and more than this with improved facilities for heating the rivets. The bar was devised by Mr. John B. Smith, boiler shop foreman, and we are indebted to Mr. L. H. Babcock, one of the boiler makers, for the sketch.

ROUND THE WORLD IN FORTY-ONE DAYS.—The tour of the world in 80 days, which formed the basis of one of Jules Verne's fascinating romances about 35 years ago, would seem a very slow performance nowadays. Lieut.-Colonel Burnley-Campbell, in a letter to the *Times*, recently described how he did it in little more than half that time. Traveling by the Canadian Pacific route, he left Liverpool on May 3rd, reached Vancouver on May 14th, and Yokohama on May 26th. Departing thence next evening he traveled across the island by rail to Tsaruga, and sailing from that port, a few hours later landed at Vladivostok on May 30th, where he caught the trans-Siberian train for Moscow, and arrived there on June 10th, and finishing the journey via Warsaw, Berlin, Cologne, and Ostend at Dover on June 13th. The time consumed on the journey was thus 40 days, $19\frac{1}{2}$ hours, and another seven hours would have enabled him to reach Liverpool. The journey shows what the Siberian railroad has done in increasing the rapidity of communication, for before that line was constructed the feat would have been impossible.—*The Mechanical Engineer*.

WEALTH PER CAPITA.—The wealth per capita is $1,125 in the United States as a whole, $1,455 in Great Britain, $1,228 in France, $751 in Germany, $1,247 in Australia and $2,800 in California.

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We hear much as to the advantages of high speed tool steels in railroad shops, but it is doubtful if many of our shop managers have any definite idea as to how much these steels are costing them to do a certain amount of work, or as to the comparative advantages of the various makes of these steels. The description of the service tests made at the Collinwood shops, page 348, is of value in this connection, as it outlines a simple, inexpensive method of obtaining this information with a fair degree of accuracy.

DISTRIBUTION OF LABOR CHARGES IN A RAILROAD REPAIR SHOP.

At the main repair shops of one large railroad system in which 454 locomotives were repaired during the past year, 231 of them at a labor cost of more than $400 apiece, the distribution of the cost of labor was as follows:

	Per Cent.
Erecting Shop	30.2
Machine Shop	25.6
Boiler Shop	18.8
Smith Shop	9.1
Tin Shop	6.1
Cab, Tender Frames and Trucks	4.4
Paint Shop	2.0
Roundhouse and Miscellaneous	3.8
Total	100.0

The total labor cost was in excess of $250,000. These figures convey a good idea of the relative size and importance of the various departments.

TEAM-WORK.

The necessity of team-work and co-operation in and between each department of a railroad has been mentioned many times in these columns. How an official, or a department, who is continually looking for an opportunity to find fault with another official or department, or how one department going on regardless of the interests of and without co-operating with the others, can hope to make a real record or success of its work, is hard to understand.

Mr. Wheatley's article, on another page, suggests a number of ways in which the operating department can help the mechanical department to accomplish better results. The last paragraph which suggests that the title of the master mechanic be changed to assistant superintendent is a little startling and should receive careful consideration. The idea is to automatically secure closer co-operation between the two departments and to open up greater opportunities for the motive power official.

SYSTEM.

The following sentiments, which were expressed by one of our friends who is engaged in trying to introduce some system into motive power affairs, is worthy of consideration.

"A better and more expensive engineer was needed to stop the flow into the Salton Sea when the break had been made than is needed to keep the Colorado River where it belongs now the break is closed. Sensational work, such as damming the Colorado River, putting a ship off the rocks, or keeping engines going after they are in such shape that every one is looking on, is more exciting and pleasing than plodding along with systematic detail daily work. Systematic detail work keeps everything going properly but cuts out the chance of having the limelight thrown upon the performer."

"This element of pride and self-glory makes the ordinary man of authority plant his feet and balk when system is proposed. He wants to do everything himself and get all the glory. If records and system are applied he feels that a set of clerks will do his work. He knows that if system is applied rigidly enough the proper course will be as plain as the channel into a harbor marked with lighthouses and buoys. Columbus is more of a hero than the sea captain of to-day who courses the ocean with charts, lighthouses and marked channels to guide him. Systematic records are the lighthouses and buoys which mark the channels through which the man in authority should sail his

affairs. This man, however, realizes that his personal glory dwindles when he sails in charted seas. Hence he says no system for me."

The suggestion might be made that those who fear that their personal glory will dwindle when sailing in charted seas should "get busy" and chart the seas. There is certainly more glory in charting than in sailing to someone else's charts. Instead of saying "no system for me," let them "get busy" in making a system and then it will not be necessary for it to be proposed to them.

THE SUCCESSFUL MOTIVE POWER DEPARTMENT OFFICIAL.

Here are the principles or rules which were followed by one of the most successful of our motive power officials.

I.—"Cover current practice with circulars giving explicit instructions in detail for all employees. Make these instructions definite and keep them strictly up to date."

II.—"Establish measures of expenditure for the maintenance and repairs of equipment, fuel, etc., and see that they are not exceeded." This can only be done by carefully studying and analyzing conditions and making a fair allowance for the various items, or in other words, establishing a limit which those interested should strive to reach and keep within. Such a limit should, of course, be a reasonable one and such that can be reached by careful, systematic effort. It is then a matter for those in charge to follow up cases where the limit is exceeded and apply the proper remedies. This idea has been tried to some extent, in various ways and in varying degrees, on several roads and in some instances has failed because too little attention was paid to analyzing conditions.

An extreme illustration of how this idea has been developed even to the point of setting a limit for each man to reach and determining his efficiency is shown in the paper on "Shop Cost Systems," which was presented before the Master Mechanics' Association by Mr. A. Lovell and reprinted on page 274 of our July issue, or in the paper by Mr. Harrington Emerson on "The Methods of Exact Measurement Applied to Individual and Shop Efficiency at the Topeka Shops of the Santa Fe," on page 221 of our June issue, or in the paper by Mr. J. F. Whiteford on "Roundhouse Betterment Work" on page 216 of our June issue.

Another illustration of this idea is that of placing locomotives on an allowance plan or establishing a cost at which each engine should be maintained. To be a success the performance sheets must be more accurately and carefully compiled and more promptly issued than is now done on many roads. This system has been used on the Northern Pacific Railway for some years. It is also in use on the Canadian Pacific Railway. The method of keeping the performance sheets on the latter road was considered at length in an article by Mr. H. H. Vaughan in our June, 1906, issue.

III.—"Cut out lost motion everywhere by keeping a minute record of pay-rolls and other cost statistics." In order to digest and quickly draw accurate conclusions from the mass of statistics which pass through the hands of the motive power officials they must be plotted graphically. The method of doing this in the mechanical department of the Northern Pacific Railway was described by Mr. L. A. Larsen, on page 451 of our December, 1905, issue. This system was first used extensively on the Chicago, Great Western Railway.

IV.—"Know positively what is doing."

V.—"Know what everything costs."

VI.—"Know what it ought to cost."

VII.—"Establish an organization which is automatic and will not suffer by the loss of an official—even the highest." This is, of course, the most difficult part of the problem. It depends to a large extent on having fully carried out and established the principles noted above, and to do this requires time and loyal and enthusiastic assistants. Unfortunately, too many of the men who have undertaken the problem and have gone far toward its solution have found it to their advantage to leave the service and go where their efforts were appreciated to a greater extent. Fortunately some of the railroads have realized the importance of keeping such men. It is to be hoped that more of them will do so.

THE ECONOMICAL UTILIZATION OF LABOR.*

By Henry L. Gantt.

Those who have given even superficial study to the subject of labor are beginning to realize the enormous gain that can be made in the efficiency of workmen if they are properly directed and provided with proper appliances. Few, however, have realized another fact of equal importance, namely, that to maintain *permanently* this increase of efficiency the workman must be allowed a portion of the benefit derived from it. To successfully obtain a high degree of efficiency, however, the same careful scientific analysis and investigation must be applied to every labor detail as the chemist or biologist applies to his work. Wherever this has been done, it has been found possible to reduce expenses and at the same time to increase wages, producing a condition satisfactory to both employer and employee.

Wherever any attempt is made to do work economically the compensation of the workman is based more or less accurately on the efficiency of his labor. Very fair success in doing this has been accomplished in day work by keeping an exact record of the work done each day by every man and by fixing his compensation accordingly. This method, however, falls very far short of the highest efficiency, for very few workmen know the best way of doing a piece of work, and scarcely any have the ability to investigate different methods and select the best. It often happens, then, that a man working as hard as he can falls very far short of what may be done, on account of employing inferior methods, inferior tools, or both.

We can never be certain that we have devised the best and most efficient method of doing a piece of work until we have subjected our methods to the criticism of a complete scientific investigation. Many people who have been accustomed to seeing an operation performed in a certain way, or even to performing it in that way for a number of years, imagine they know all about it, and resent the intimation that there may be some better way of doing it. Anybody, however, who carefully analyzes the sources of his methods will find that the mass of them are either inherited, so to speak, from his predecessor, or copied from his contemporaries. He will find that he knows but little of their real origin, and consequently has no ground on which to base an opinion as to their efficiency.

Even such a simple operation as shoveling is done very uneconomically in many places. The writer has seen the same shovel used for coal, ashes and shavings, and this when coke forks were available for the shavings. The foreman had apparently given the subject no study and was content if the men were at work. The idea of working efficiently had never occurred to him. This is, of course, an extreme case, but it is a real one, and all degrees of efficiency exist between this and the case where each workman is provided with the proper implement and given a specific task, for the accomplishment of which he is awarded extra compensation.

Having determined thus the amount of work that a man can do, we can usually get it done if we offer the proper wages for doing it, and furnish an instructor who will teach the workman how to do it. If the best method of doing a task is taught to a capable workman to whom good wages is paid for its successful performance, it would seem that we had done enough to assure the work's being done that way permanently. Such, however, is not the fact, for while these conditions will usually produce the desired result, they will not always maintain it, but must be supplemented by a fourth condition, namely, *a distinct loss in wages on the part of the workman unless a certain degree of efficiency is maintained.*

In order to get the best results the following four conditions are necessary: *First.* Complete and exact knowledge of the best way of doing the work, proper appliances and materials. *Second.* An instructor competent and willing to teach the workman how to make use of this information. *Third.* Wages for efficient work high enough to make a competent man feel that they

* Abstracts from a lecture delivered to the Senior Class of Stevens Institute of Technology.

are worth striving for. *Fourth.* A distinct loss in wages in case a certain degree of efficiency is not maintained. These four conditions for efficient work were first enunciated by Mr. Fred W. Taylor, and when they are understood their truth seems almost axiomatic. They are worthy of very careful consideration.

These conditions are really the steps that must be taken to get any piece of work done efficiently: *First.* Learn how to do it right, and how long it should take. *Second.* Teach a workman to do it in the manner and time set. *Third.* Award the workman greater compensation for doing it in the manner and time set than he can ordinarily earn in any other manner. *Fourth.* Make the conditions of pay such that if he fails to do the work either in the manner or time set, he gets only his day's pay.

Let us study these steps one at a time. The first is a scientific investigation of how to do the work and how long it should take. The fact that any operation, no matter how complicated, can be resolved into a series of simple operations, is the key to the solution of many problems. Study leads us to the conclusion that complicated operations are always composed of a number of simple operations, and that the number of elementary operations is often smaller than the number of complicated operations of which they form the parts. The logical method, therefore, of studying a complicated operation is to study the simple operations of which it is composed, a thorough knowledge of which will always throw a great deal of light on the complex operation. Also the time needed for performing any complex operation depends upon the time of performing the simple operations of which it is composed. The natural method, then, of studying a complex operation is to study its component elementary operations. Such an investigation divides itself into three parts, as follows: An analysis of the operation into its elements; a study of these elements separately; a synthesis, or putting together the results of our study.

This is recognized at once as simply the ordinary scientific method of procedure when it is desired to make any kind of an investigation, and it is well known that until this method was adopted science made practically no progress. If it is desired to obtain the correct solution of any problem we must follow the well-beaten paths of scientific investigation, which alone have led to reliable results. The ordinary man, whether mechanic or laborer, if left to himself, seldom performs any operation in the manner most economical, either of time or labor; and it has been conclusively proven that even on ordinary day work a decided advantage can be gained by giving men instructions as to how to perform the work they are set to do. When these instructions are the result of scientific investigation, the gain in efficiency is usually beyond our highest expectations.

It is well known that nearly every operation can be and in actual work is, performed in a number of different ways; and it is self-evident that all of these ways are not equally efficient. As a rule, some of the methods employed are so obviously inefficient that they may be discarded at once, but it is often a problem of considerable difficulty to find out the very best method. It is only by a scientific investigation that we can hope even to approximate the best solution of any problem.

To analyze every job and make out instructions as to how to perform each of the elementary operations requires a great deal of knowledge, much of which is very difficult to acquire; but the results obtained by this method of working are so great that the expenditure to acquire the knowledge is comparatively insignificant.

It has been demonstrated that whether the labor is that of a Pennsylvania Dutch workman in a machine shop, a Hungarian laborer handling stock in the yard of a steel-works, or a skilled cloth handler in a bleachery, the amount of work the average workman does under the ordinary conditions is only about one-third of what can be done by a proper workman under the best conditions. I could give other illustrations of this ratio, which seems to be pretty uniform. In other words, when a man sets his own task, as he virtually does in ordinary day work, he usually does about one-third of what a good man fitted for the work can do under the best conditions.

As a result of our first step or our scientific investigation, we find, in general, that it is possible to do about three times as much as is being done; the next problem is how to get it done. First, I wish to say that no matter how thoroughly convinced we may be of the proper method of doing a piece of work and of the time it should take, we cannot make a man do it unless he is convinced that in the long run it will be to his advantage. In other words, we must go about the work in such a manner that the workman will have confidence in us and feel that the compensation offered will be permanent. When we have established this condition of affairs we are ready to start a workman on the task, which, when properly set after an investigation, is such as can be done only by a skilled workman working at his best normal speed.

The average workman will seldom be able at first to do more than two-thirds of the task, and as a rule not more than one out of five will be able to perform the task at first. By constant effort, however, the best workmen soon become efficient, and even the slower ones often learn to perform tasks which for months seemed entirely beyond them.

If we have at hand such people that already have confidence in us and are willing to do as we ask, the problem of getting our task work started is easy. This, however, is frequently not the case, and a long course of training is necessary before we can teach even one workman to perform his task regularly, for workmen are very reluctant to go through a course of training to get a reward, especially when they are being told on all sides, as is usually the case, that the high price offered will be cut as soon as they can earn it easily.

Buying labor is one of the most important operations in modern manufacturing, yet it is one that is given the least amount of study. Most shops have expert financiers, expert designers, expert salesmen, and expert purchasing agents for everything except labor. The buying of labor is usually left to people whose special work is something else, with the result that it is usually done in a manner that is very unsatisfactory to buyer and seller. It is admitted to be the hardest problem we have to face in manufacturing to-day, and yet it is considered only when the manager "has time" or "has to take time," or on account of "labor trouble." The time to study this subject is not when labor trouble is brewing, but when things are running smoothly and employer and employee have confidence in each other.

Men as a whole (not mechanics only) prefer to sell their time rather than their labor, and to perform in that time the amount of labor they consider proper for the pay received. In other words, they prefer to work by the day and be themselves the judges of the amount of work they shall do in that day, thus fixing absolutely the price of labor without regard to the wishes of the employer who pays the bill. While men prefer as a rule to sell their time and themselves determine the amount of work they will do in that time, a very large number of them are willing to do any reasonable amount of work the employer may specify in that time, provided only they are shown how it can be done and paid substantial additional amounts of money for doing it. The additional amount needed to make men do as much work as they can depends upon how hard or disagreeable the work is, and varies from twenty to one hundred per cent. of their day rate.

These facts are derived from experience and give us a key to the intelligent purchase of labor. For instance, if we wish to buy the amount of labor needed to accomplish a certain task, we must find out exactly and in detail the best method of doing the work, and then how many hours' labor of a man suited to the task, working at his best normal rate and by the methods prescribed, are needed to perform it.

This is simply getting up a set of specifications for the labor we wish to buy, and is directly comparable to a set of specifications for a machine or a machine tool. The man who buys the latter without specifications is often disappointed, even though the manufacturer may have tried earnestly to anticipate his wishes; and the man who buys the former under the same conditions has in the past almost universally found that a revision of his contract price was necessary in a short time. The relative

importance of buying labor and machinery according to the best knowledge we can get, and the best specifications we can devise, is best illustrated by the fact that while the purchase price of a machine may be changed whenever a new one is bought, that of the labor needed to do a piece of work should be practically permanent when it is once fixed. As I have said before, few men can work up to these specifications at first, if they are properly drawn, but many men will try if they are properly instructed and assured of the ultimate permanent reward. Most men will not sacrifice their present wages to earn a higher reward in the future, and even if they were willing, few men could afford to. Therefore, while they are learning to perform the task, they must then be able to earn their usual daily wages, and the reward for the accomplishment of the task must come in the form of a bonus over and above their daily wage.

It is these considerations that lead to the development of the bonus system of paying labor, under which a man always gets his day's wages. If he accomplishes the task in the time and manner specified, he gets in addition a bonus the size of which depends upon the severity of the work. The easiest way to figure such a bonus is to make it a proportion of the time allowed; for instance, if from our time study we find that three hours is a reasonable time for a job that has usually taken from five to ten hours, we set three hours as the time limit and pay the workman one-third more, or for four hours, if he does the work in three hours or less.

If he does it in exactly three hours he gets pay for four hours, or an increase of $33\frac{1}{3}$ per cent. If the work is done in two and one-half hours he gets pay for four hours, or an increase in wages per hour of 60 per cent. If the work is done in two hours his pay is still that which he would ordinarily get for four hours, an increase of 100 per cent. If the study of the work has been carefully done, and the task is properly set, it will but seldom occur that a workman can do in two hours the task for which he was allowed three. We sometimes find, however, that an exceptional man will do in two and one-half hours work that a good man will need three hours for. The large increase of wages such a man can earn amply compensates the exceptional man for devoting his time to the work.

As I have said before, a proper task is always greater than the ordinary workman can perform at first, and must be such as only the most skilled can perform. On the other hand, when the more skilled have been earning their bonus for some time, and the less skilled began to realize that the prize is real and worth striving for, they make every effort to attain it and rapidly improve in skill. This increase in efficiency makes the payment of high wages possible, and it may be added that without efficient labor, permanent high wages cannot be paid indefinitely, for *every wasteful operation, every mistake, every useless move has to be paid for by somebody and in the long run the workman has to bear his share.*

Good management, in which the number of mistakes is reduced to a minimum, and useless, or wasteful operations eliminated, is so different from poor management, in which no systematic attempt is made to do away with these troubles, that a man who has always worked under the latter finds it extremely difficult to form a conception of the former. The best type of management is that in which all the available knowledge is utilized to plan all work, and when the work is done strictly in accordance with the plans made. In other words, that management is best which utilizes labor in the most efficient manner.

The best mechanical equipment of a plant that money can buy avails but little if labor is not properly utilized. On the other hand, the efficient utilization of labor will often overcome the handicap of a very poor mechanical equipment, and an engineer can have no greater asset than the ability to handle labor efficiently.

IMMIGRANTS.—The number of immigrants admitted to the United States during the year ending June 30, 1907, was 1,285,349. The number admitted during the previous year, 1906, was 1,100-735; for 1905, 1,026,499, and for 1904, 812,870. During the past ten years, 7,208,746 have been admitted.

TEAMWORK.

The motto of the *Santa Fe Employees' Magazine* is "Teamwork." The following example of what may be accomplished by intelligent co-operation or teamwork is cited in its August issue:

"Some time ago, with a view of ascertaining the facts in regard to the amount of material held at the shops and by section forces, extra gangs, and, in fact, all material other than that in the custody of the store department, a thorough examination was made, which resulted in the determination to collect and turn back into stock all the material not actually needed for current uses. As the undertaking progressed large amounts of material and supplies were found. Some of this was obsolete and was sold; in fact, special pains were taken to gather up and sell all of the scrap available. The value of material taken back into stock from various sources mentioned above, during the year ending June 30, was \$1,035,032.43. The scrap sales amounted to \$1,988,793.65."

"Mr. Rice, the general storekeeper of the company, in submitting his report upon this subject, said: 'A great deal of the credit for the proper and prompt handling of scrap is due to the transportation department as well as to the mechanical department. We have had the very best support from both departments in properly taking care of the scrap during the past year. The same holds good with material taken back into stock, all of which has been credited to operating accounts. The figures that I have submitted show plainly the results that can be obtained by hearty co-operation between all departments. As stated before, however, the credit for the large increase shown in the figures is due to no particular person; it is 'teamwork' between the officials and employees of the transportation, mechanical and store departments.' "

LENGTH OF A CURVED LINE.

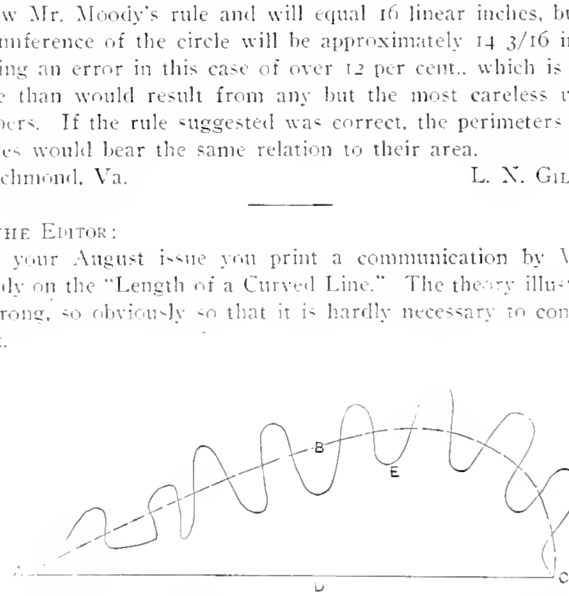
TO THE EDITOR:

On page 309 of your August number I note a method for finding the length of a curved line. This is wrong as can readily be seen by considering the length of the perimeter of a square and a circle, of equal area. Consider a circle and a square each containing 16 square inches. The perimeter of the square will of course follow Mr. Moody's rule and will equal 16 linear inches, but the circumference of the circle will be approximately 14 3/16 inches, making an error in this case of over 12 per cent., which is much more than would result from any but the most careless use of steppers. If the rule suggested was correct, the perimeters of all figures would bear the same relation to their area.

Richmond, Va. L. N. GILLIS.

TO THE EDITOR:

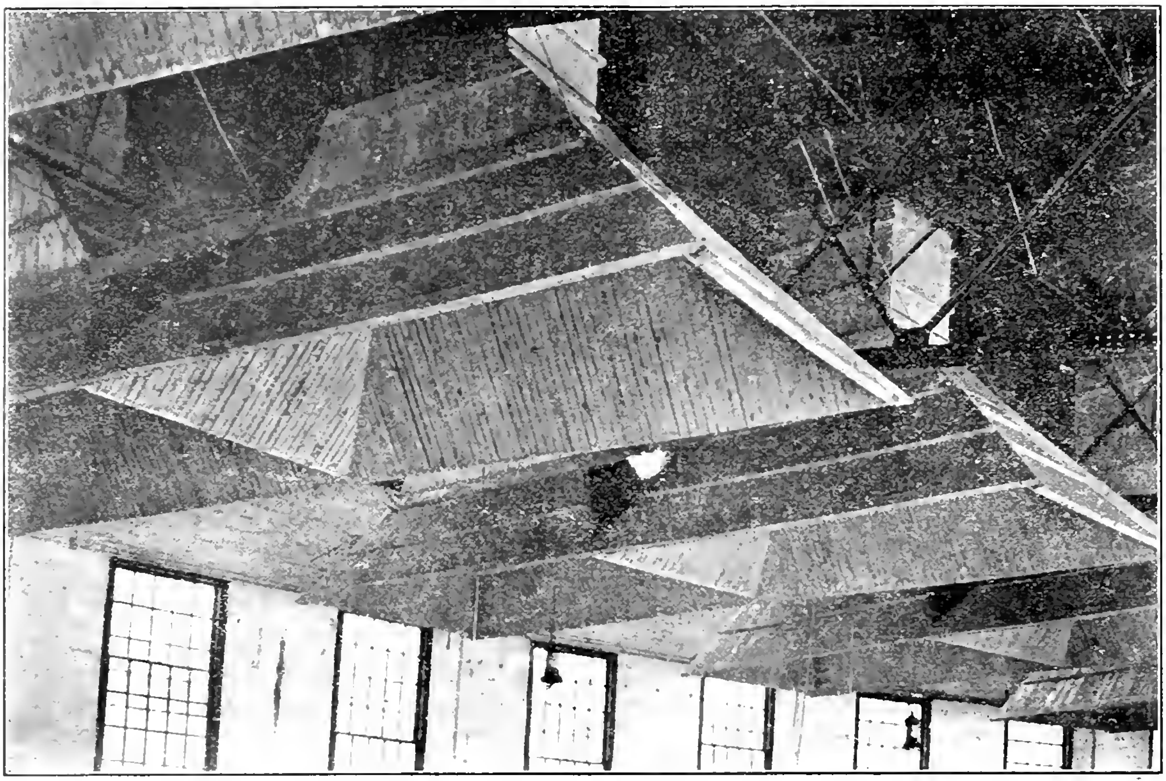
In your August issue you print a communication by W. O. Moody on the "Length of a Curved Line." The theory illustrated is wrong, so obviously so that it is hardly necessary to comment on it.



According to Mr. Moody, if the areas ABCD and AECD are equal, the dotted line ABC and the full line AEC, are of the same length, whereas the full line is really much longer than the dotted line. JOHN E. GARDNER.

Aurora, Ill.

NUMBER OF AUTOMOBILES BUILT.—A French statistician estimates that about 550,000 motor cars have been manufactured in the nine years since the experiments of self-propelled road vehicles first succeeded, and these machines sold for more than \$1,000,000,000.



DOUBLE SMOKE JACK—PITTSBURGH & LAKE ERIE RAILROAD.

AN EVOLUTION IN ROUNDHOUSE SMOKE JACKS.

PITTSBURGH & LAKE ERIE RAILROAD.

The Pittsburgh & Lake Erie Railroad was one of the first to experiment with and adopt a smoke jack with a very large opening at the bottom, such as is now coming into quite general use. Fig. 1 shows the first example of this type, which was introduced on that road in 1903. The end doors did not prove satisfactory and the slope to the stack was not steep enough and offered more or less resistance to the smoke and gas. This was succeeded by the type of jack shown in Fig. 2. The end doors were done away with and the slope to the stack was made considerably steeper than on the earlier type, with the result that the smoke and gases passed off more readily. While this was very much more satisfactory than any other type of smoke jack which had been used up to that time, the result was still not all that was to be desired and recently the form of jack shown in Fig. 3 was adopted. This is a double jack, having two openings through the roof, and is of such length that not only does all of the smoke from the stack pass into it, but also any steam from the pop valve and whistle or other parts of the locomotive.

The opening at the bottom, 35 ft. long and 10 ft. wide, is $2\frac{1}{2}$ times as long and about $2\frac{1}{2}$ times as wide as the earlier types. The section through the upper part of each stack of the double jack is a rectangular shape 3 ft. 6 in. wide by 5 ft. long, in place of a circular section 30 in. in diameter as used with the earlier single jack. The area of each stack has therefore been increased from 700 to 2520 sq. in., the total stack opening for the double jack being 5040 sq. in., or seven times as large as that of the older types. The details of the construction are clearly shown on the drawings. The jack is of wood, the side-boards being ¾ x $3\frac{1}{2}$ in. pine flooring thoroughly dried. The T and G joints are painted with fire resisting paint before being laid. The interior surface of the jack is made as smooth as possible to avoid a lodging place for sparks, and is painted with three coats of Quest cold water paint, manufactured by Mr. W. O. Quest, McKees Rocks, Pa. The outside surface below the roof is painted with two coats of white lead linseed oil paint, and the outside surface above

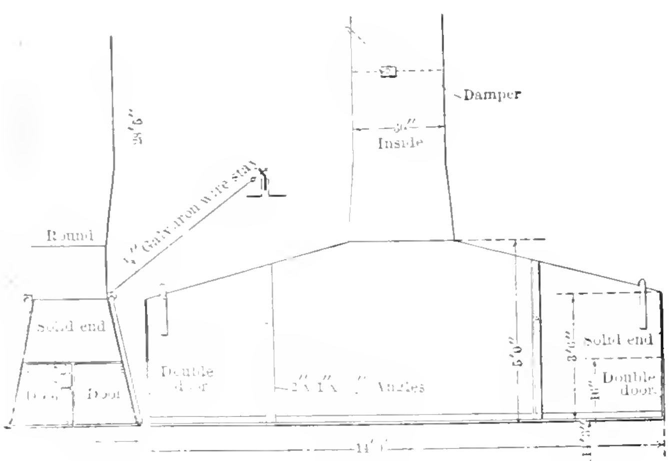


FIG. 1.—FIRST TYPE OF SMOKE JACK WITH LARGE OPENING

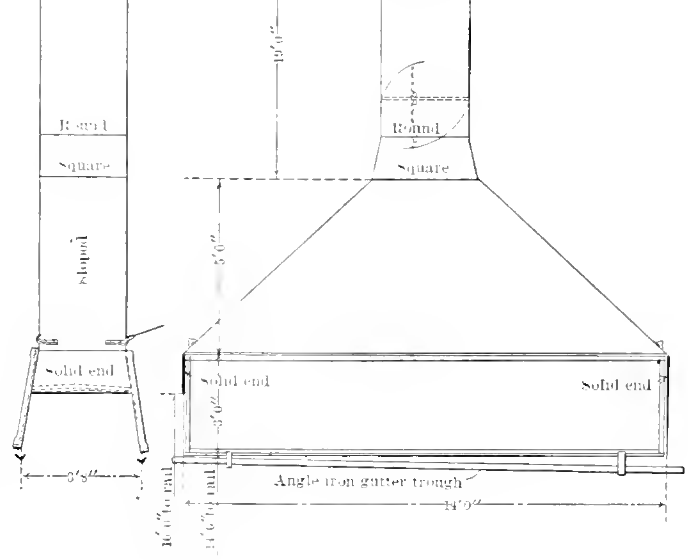


FIG. 2.—SECOND TYPE OF SMOKE JACK

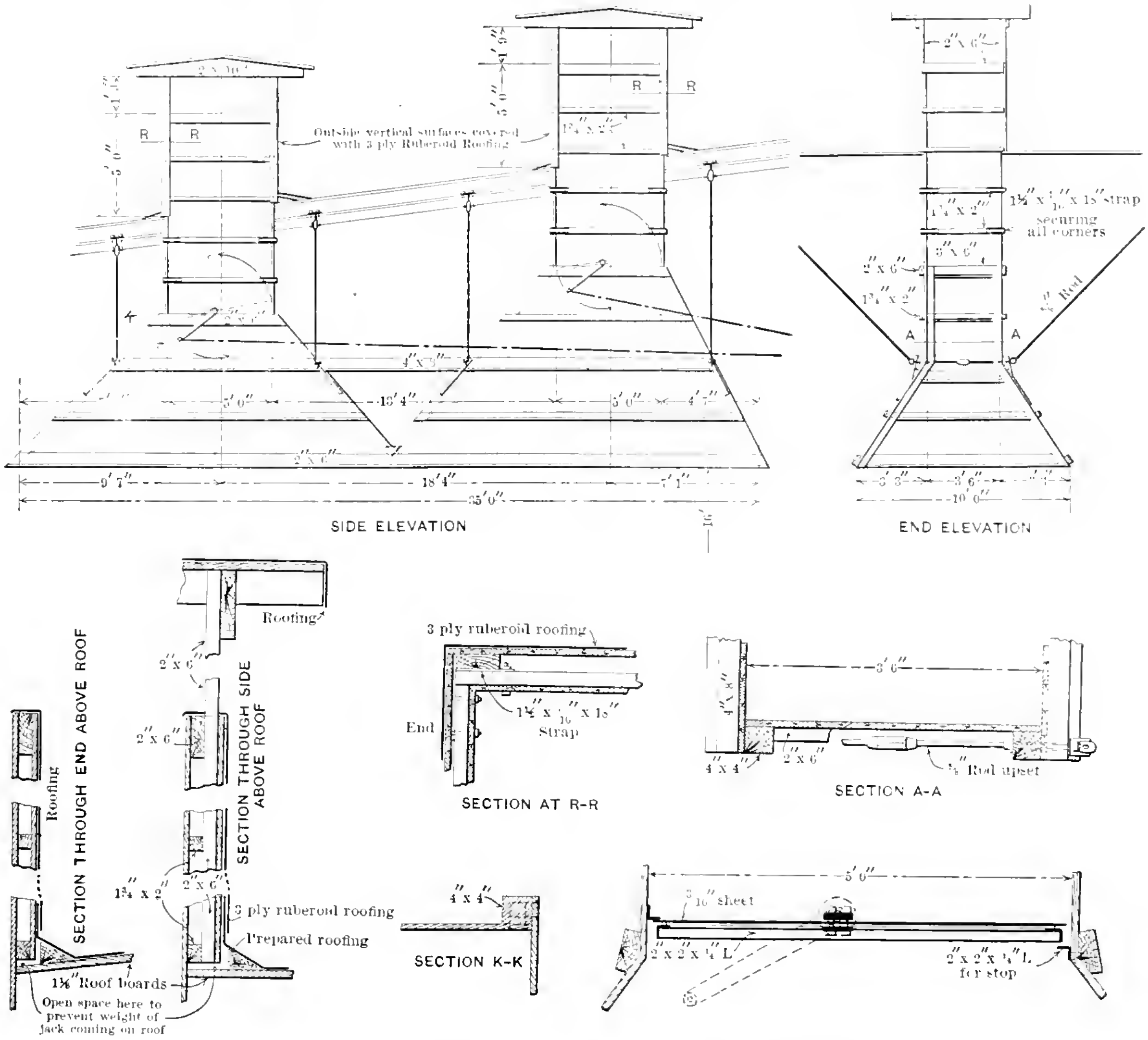
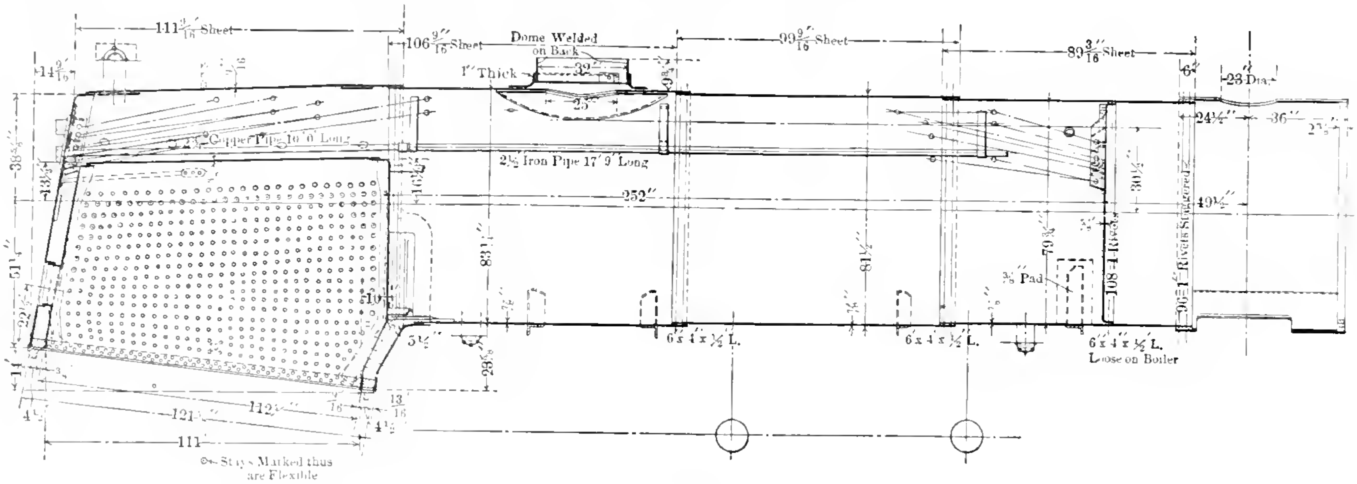


FIG. 3.—ARRANGEMENT AND DETAILS OF DOUBLE SMOKE JACK.

the roof, where Ruberoid roofing is not specified, is painted with three coats of the same paint. These jacks have been in use at three of the roundhouses (Newell, College and New Castle Junction) for some time, and have given very satisfactory results. We are indebted to Mr. A. R. Raymer, assistant chief engineer, for drawings and information.

The Steam Trials of the Lusitania.—To those most directly interested in the results of these trials of this great Cunard liner, which is one of the two largest vessels that ever left the ways in a builder's yard, as well as to those who travel over the Atlantic highway, and, indeed, to the nation as well, the evidences of superiority in speed, in comparative absence of vibration, and in general comfort and convenience aboard, must appear eminently satisfactory. But to engineers chiefly, and to those who have watched the progress of naval architecture and engineering ever since the steam turbine seriously challenged the supremacy of the reciprocating engine, the information gained in the engine room of this steamer during her 2,000 miles trial voyage is especially interesting, as it settles, as far as a trial can settle, certain questions about which engineers were divided, and upon which no experimental data on such a scale before existed. In the first place, though the turbine was chosen for this vessel, after careful consideration of the problem, as being the only engine capable of exerting the requisite power in the space accorded to the machinery, doubts existed as to the power which could be developed by this new type of engine built on a design of unprecedented size, and driving screw propellers at a speed some two and a half times that at which marine shafts of comparable size usually revolve. Notwithstanding the absence of information on the working of such gigantic turbines, not to mention the many constructive difficulties which presented themselves, the 64,600-horse-power developed, as measured by the torsion dynamometers, has fully confirmed the calculations, and the ship maintained a mean speed of 25.4 knots over the course, which was considerably better than the contract demanded. To attain such a result without the assistance of experimental facts on a similar scale represents the exercise of the greatest skill and scientific precision, which ought to dispose of the contention sometimes made that steam turbine design is executed by rule of thumb and hit and miss principles rather than by judgment combined with mathematical calculation and such experimental knowledge as is available.—*From the Times (London) Engineering Supplement.*

Study Men.—To attain to the highest success as an engineer you should not only be able to reach correct conclusions quickly when you have the facts before you for direct observation, but you should also have the power to draw correct conclusions quickly from information which comes to you through other men. This power comes largely from knowing men. To attain to the highest success as an engineer you must not be the type of a man who knows how to do things excellently but cannot tell others how to do them—the man who gets knowledge abundantly but can apply it only through his own fingers. Instead of devoting your energy simply to increasing your own output by 50 or even 100 per cent., it is far better—you make yourself more useful to the world—by using your energy to increase the output of each of one hundred men by 10 per cent. The world recognizes this by awarding the prizes to the administrators.—*Mr. John F. Hayford, at the Thomas S. Clarkson Memorial School of Technology.*



LONGITUDINAL SECTION THROUGH BOILER—PENNSYLVANIA RAILROAD PACIFIC TYPE LOCOMOTIVE.

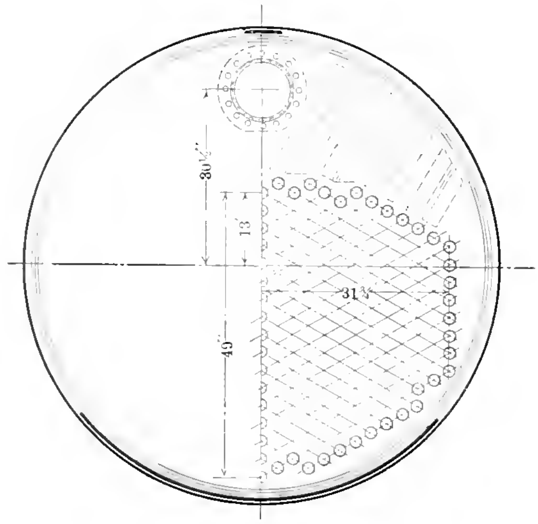
LARGEST PASSENGER LOCOMOTIVE.

PENNSYLVANIA RAILROAD.

In the July issue of this journal, pages 266 and 267, appeared the general elevation, photograph and a brief description, with dimensions, of the largest passenger locomotive ever built, which was recently completed at the Pittsburg shops of the American Locomotive Company, for the Pennsylvania Railroad.

This locomotive has 24 x 26 in. simple cylinders, carries 205 lbs. boiler pressure and weighs in working order 269,200 lbs. The tractive effort with 80 in. drivers, is 32,700 lbs. As supplementary to the general description given in that article the more important details are considered in this article.

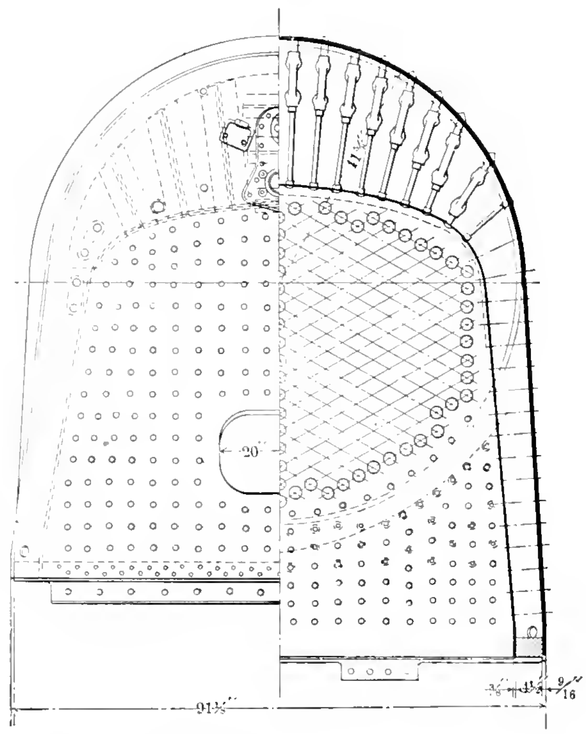
Boiler.—The boiler is of the straight top radial stay type, measuring 79¾ in. outside diameter at the front ring and 83¼ in. outside diameter at the dome course. The tubes are 21 ft. in



CROSS SECTIONS THROUGH BOILER.

length, 2¼ in. in diameter, and 343 in number. This number of tubes occupies but 27.2 per cent. of the area of the boiler at the front tube sheet, a figure somewhat lower than is ordinarily found in recent large boilers. The arrangement of the tubes in the sheet is shown in one of the illustrations; they are set with 13/16 in. bridges. The shell is made up of three cylindrical sheets, each of them ⅞ in. thick and varying from 89 3/16 in. to 106 9/16 in. in length. The front tube sheet is set some distance back into the first barrel sheet, making it 49½ in. back of the center line of the stack and giving a front end 85½ in. in length, a figure somewhat larger than the diameter of the front end.

The grate area is 68.8 sq. ft., making it the largest grate of any passenger locomotive burning soft coal, on our records. The grate slopes forward, the front end being 14 in. lower than at the back and giving a throat over 23 in. in depth. The mud ring is 4½ in. wide on all sides, the water spaces being somewhat wider near the top. Both the outside and inside sheets slope inward due to the extreme width of 80¼ in. at the grate level. The crown stays are fitted with turnbuckles so that they can be adjusted and each will bear its proper share of the load. The injector feed is through an internal pipe, as has been the custom on the Pennsylvania Railroad for some time, this pipe coming from a double check valve chamber on the back head, and consisting of a 2¾ in. copper pipe, to a point just ahead of the crown sheet, where it is continued by a 2½ in. iron pipe to a discharge at about the water level near the front tube sheet. The grate is served by a single fire door 20 in. wide, set 22½

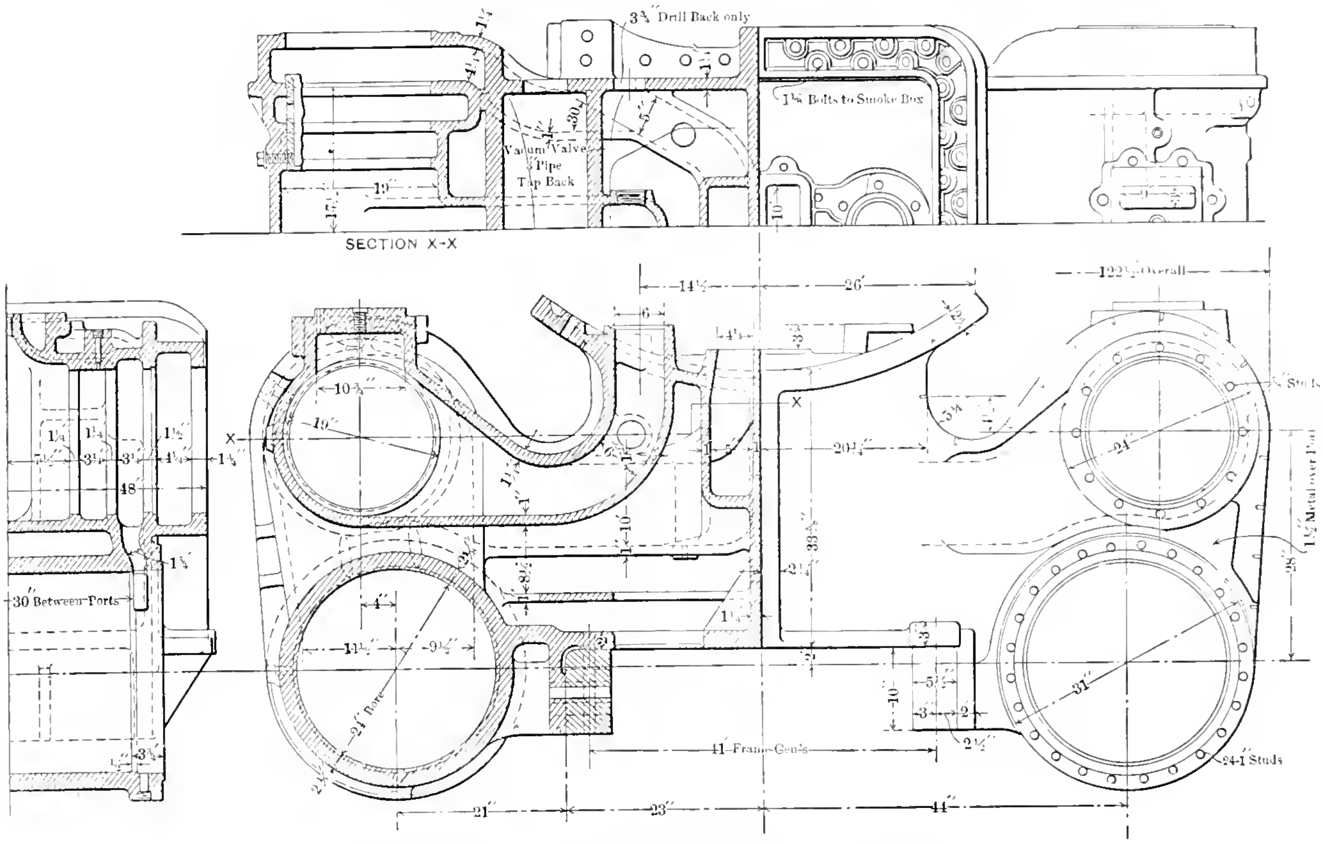


HALF VIEW OF REAR HEAD AND SECTION THROUGH FIREBOX.

in. above the bottom of the mud ring, or slightly above the level of the bottom of the barrel.

The boiler is supported on the frames by four plates between the cylinders and the fire-box and by a sliding support at the front end of the fire-box and a deep plate at the rear.

The placing of so large a boiler on a frame carried by 80 in. drivers has thrown it to such a height that it has been necessary to place the bell and the whistle off to one side of the center line and inclined diagonally outward so as not to exceed the clearance limits at these points. The stack is but 19½ in. high above the boiler, but is continued on the inside of the front



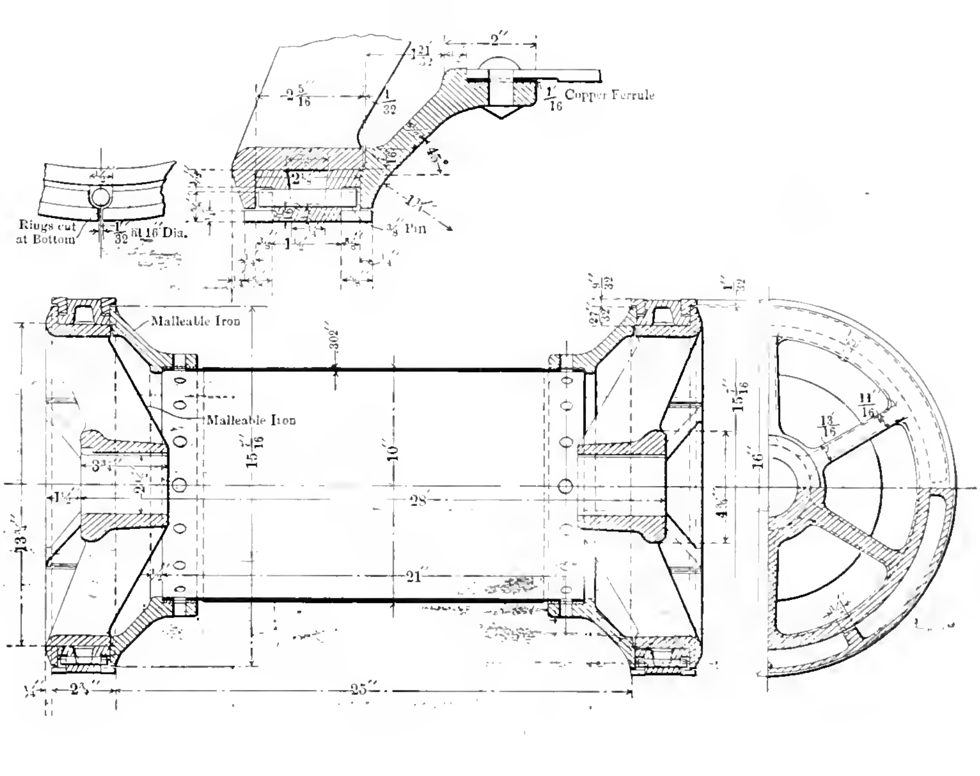
CYLINDERS—PACIFIC TYPE LOCOMOTIVE—PENNSYLVANIA RAILROAD.

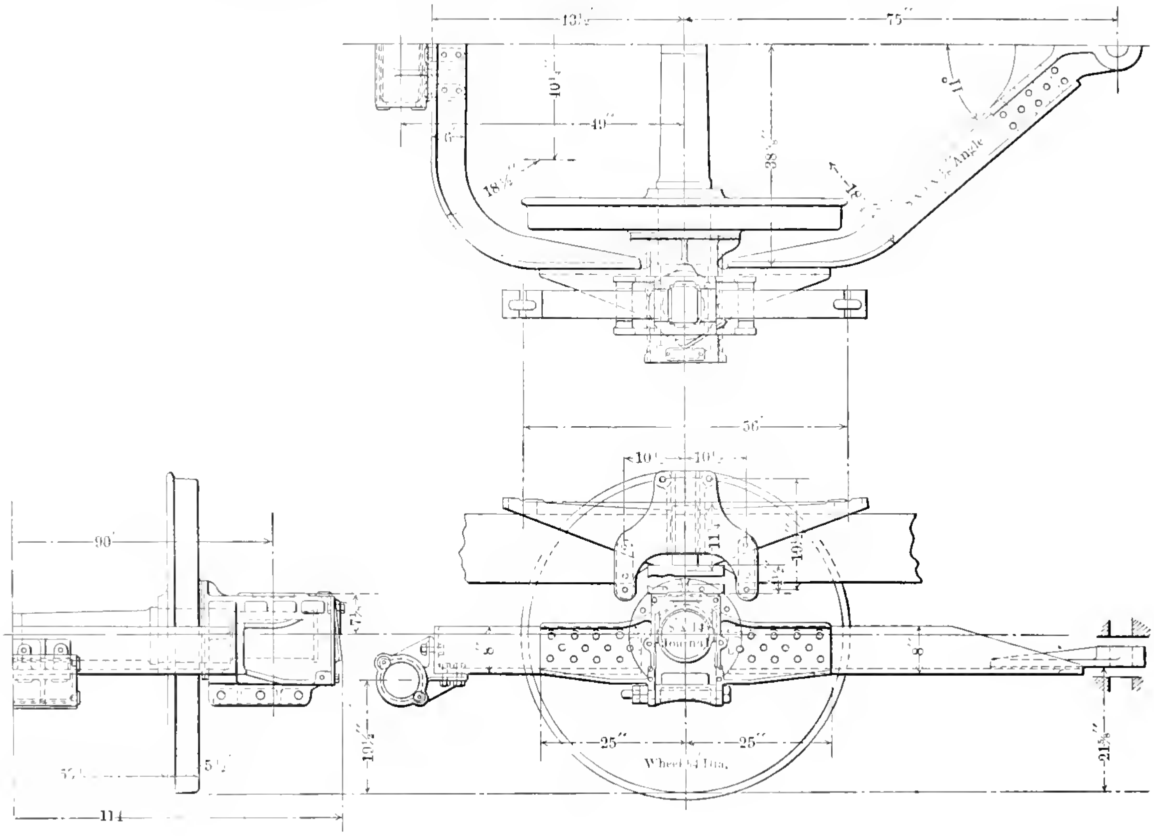
end by a draft pipe with a very large flaring bottom. The exhaust nozzle is 11⅛ in. below the center line of the boiler. The adjustable diaphragm plate is located in front of the exhaust nozzle.

Cylinders.—The accompanying illustration will show the general construction of the cylinders, which are the largest ever applied to a passenger locomotive. The chambers for the 16 in. piston valves have been thrown 4 in. outside of the center line of the cylinders in order to bring them in the same plane with the Walschaert valve gear. The steam passages have, of course, been made liberal and designed with easy curves so as to be able to furnish these very large cylinders with sufficient steam at high speed. The exhaust passage is on the outside, steam being admitted at the center of the valve chamber. The port leading from the valve chamber to the cylinders is almost straight and is 1¾ in. wide and 21 in. long where it enters the cylinder. These cylinders measure 122½ in. in width at the upper part of the valve chamber, making them wider than the bumper beam is long. They are, however, exceeded by one inch in width by the running board of the cab. The connections for relief valves, both vacuum and pressure, as well as for the lubricating pipes, are shown in the illustration.

Valves.—One of the illustrations shows a drawing of the 16 in. piston valves, which we believe are the largest piston valves ever applied to a locomotive. They have a travel of 7 in. and are made with 1 5/16 in. outside lap and ¼ in. inside clearance. They are set with a constant lead of ¼ in. The gear is of the Walschaert type and the difficulty of the location of the link with a locomotive having a four-wheel truck, has in this case been solved in a manner similar to that used on several of the recent locomotives by the use of an outside support extending from the guide yoke to a cross brace just back of the first pair of drivers. In this case, however, the support consists of two cast steel channel section bars, on which rest the bearings for the trunnion of the link, the link itself extending downward between the two bars. The connection of the radius bar to the reverse shaft is made through a slip joint. The reach rod connects directly to the vertical arm of the reverse shaft and has a bearing on the side of the fire-box just back of which is a hinged joint from which a short section connects directly to a hand operated reverse lever.

Frames.—The frames are of cast steel, the main and front



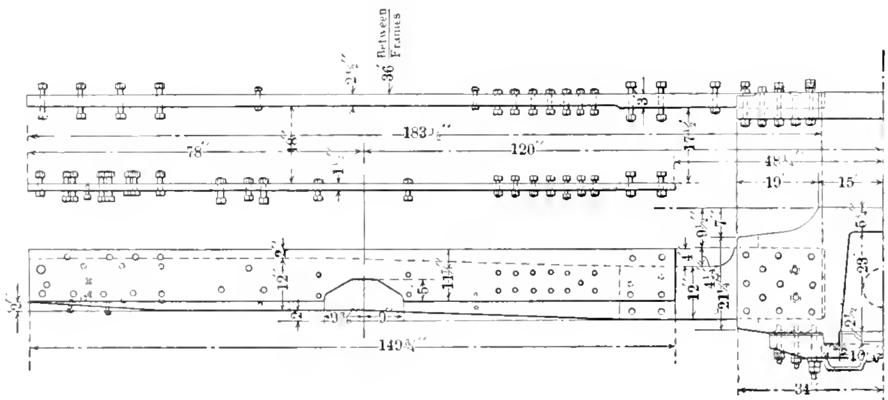


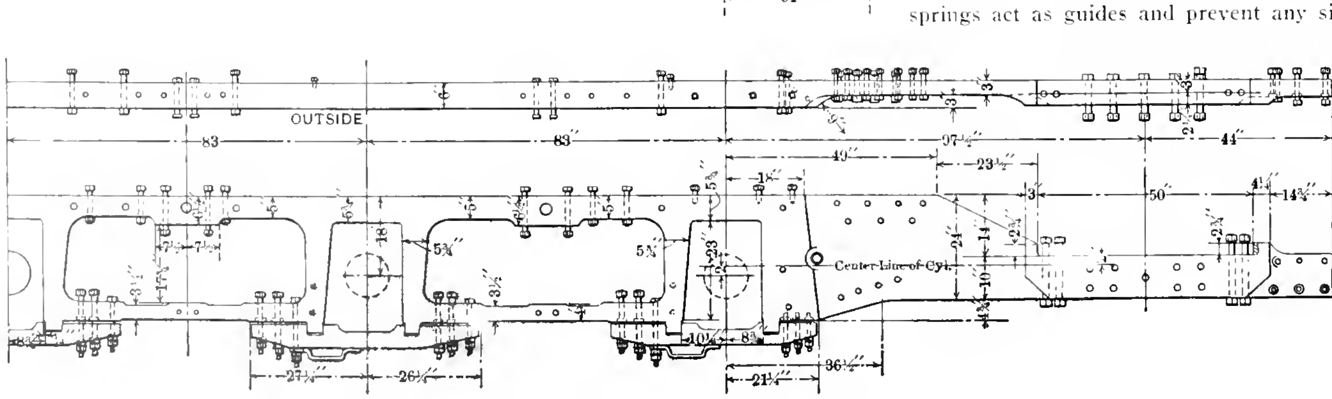
TRAILER TRUCK.

frame being in one section, which measures 6 in. in width and 5¾ in. deep at the pedestals and is 5½ x 10 in. in section below the cylinders. It assumes a plate form between the cylinders and the first driving pedestal where it is narrowed down to 3 in. in thickness and is 24 in. deep. This method gives flexibility at a point where difficulty is experienced with breakage in these very large and heavy frames. The trailer frame is in two parts, both being of plate design, the inner one being 2½ in. thick and the outer 1½ in. thick. These are spaced 18 in. apart and the trailing wheel comes between them. The inner one is securely bolted in a recess in the main frame and the outer one is secured by cast steel filling pieces at its ends.

Clip pedestal binders are used, being secured by three 1¼ in. bolts at either end. The fastening at the cylinders is by two 1⅜ in. vertical bolts front and back and by nine 1½ in. horizontal bolts. The frame bracing has been given careful attention and broad cast steel plates are secured between the upper rails at two points in the main frame, one being over the front pedestal and the other between the second and third pair of drivers. There are also several cross ties, binding the lower rails together, as well as the heavy cross bar at the front end of the fire-box.

Trailer Truck.—The accompanying illustration shows the details of the radial type of trailer truck which has been applied to this locomotive; it consists of a frame hinged at the forward end and secured by a spring centering device in the rear. The journal boxes are secured to this frame. On top of the boxes are caps arranged with grooves for rollers, the center line of the rollers being radial to the movement of the truck. Above the rollers is a cap or spring seat having similar grooves on its lower surface. The Y-shaped pieces spanning the springs act as guides and prevent any side





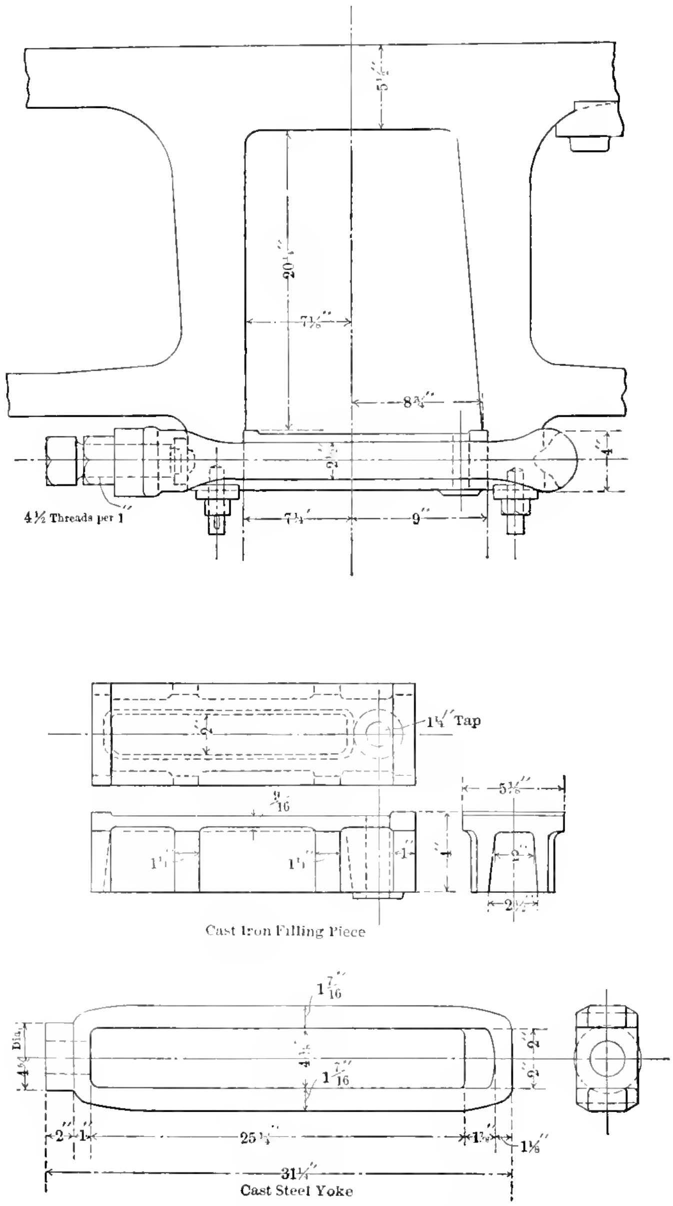
CAST STEEL FRAMES—PENNSYLVANIA PACIFIC TYPE LOCOMOTIVE.

motion of the spring or cap. The spring centering device is illustrated in the cross section of the locomotive shown on page 266 of the July issue of this journal.

The equalizing system is continued for the three drivers and trailer truck on each side of the locomotive. The springs are mounted above the frames over the boxes in every case and are secured to an equalizer located between the frame rails by hangers spanning the frames. Connection to the trailing truck is made by a long equalizer set diagonally so as to connect to the outside spring of the trailer and to the back of the spring over the rear driver, the front hanger being inside the frames.

NEW DESIGN OF PEDESTAL BINDER.

On an order of six 10-wheel passenger locomotives recently finished at the Baldwin Locomotive Works for the New York, Chicago & St. Louis Railroad, is found an interesting design of pedestal binder, which is shown in the accompanying illustra-



NEW DESIGN OF PEDESTAL BINDERS.

tion. These locomotives have 20 x 26 in. cylinders, 72 in. drivers and weigh about 156,350 lbs.

The binder consists of two principal parts, one being a cast iron filling block fitted between the jaws of the pedestal in a similar manner to that used with the large bolt type of binder. In this case, however, instead of a single large bolt passing through the jaws with its accompanying weakness at the sides of the holes, a cast steel yoke is provided which spans the pedestal jaws and the filling piece and is fitted with a 2¼ in. set screw on one end operating against a seat having a nub which fits in a recess in the outside of the jaw. A lock nut is provided on the set screw. Provision is also made for preventing the yoke from falling to the track in case the set screw becomes loosened by two clips or stops secured to the bottom of the jaw.

The cast iron filling piece is carefully designed to give lightness and the cast steel yoke is given a section at its weakest point of 1 7/16 x 2½ in., making it practically immune from breakage. Provision is made for a wedge adjusting screw.

A REGENERATIVE REVERSE PLANING MACHINE.

Under this caption the *Engineer* (London) describes an interesting planer recently brought out by Joshua Buckton & Company, Leeds, England. Recoil springs are placed near the back of the machine which are capable of absorbing the energy of the parts that move and have to be reversed, and restore, during acceleration, the energy that would otherwise be wasted. "Screws pass through these springs, and lie along the whole length of the bed. Adjustable on these screws are heavy bronze nuts, and against these nuts impinge knockers, attached in fixed position. The stroke can be adjusted while the machine is running, and the alteration in the position of the nuts does not disturb the synchronism of the belt striking motion with the spring compression."

"It will be understood that while the return stroke of the machine takes place at the constant speed of 180 ft. per minute, the cutting stroke can be varied through change-speed gearing, but although the total range of speed which gives the slowest cutting speed of 20 ft. and highest return speed of 180 ft. is in the ratio of 9 to 1, yet no adjustments are required between the highest and the slowest speed, and there is no difference in the accuracy of the line of reversal."

Ammeter diagrams, which are reproduced, indicate that the amount of power required at reversal is only slightly greater than while cutting, and in some cases is even less. An illustration of some of the work which was done on the machine shows a remarkable accuracy of reversal.

DECAPOD PUSHING LOCOMOTIVES.—The six locomotives of the 2-10-0 type recently delivered to the Buffalo, Rochester and Pittsburg Railroad by the American Locomotive Co. are in service between Clarion Junction and Freeman, Pa. At this point there is a ruling grade for north-bound trains of 58 ft. to the mile, with numerous curves, the sharpest of which are 8 degrees. Heretofore 3350 tons have been handled up this grade with two consolidation locomotives, each with a tractive effort of 38,000 pounds, one being used at the rear end as a pusher. The rating of one of the same locomotives from Punxutawney, Ernest or DuBois to the foot of the grade is 3,500 tons. With track improvements which are now in progress, it is expected that with the same class of consolidation engine it will be possible to handle 4,000 tons to the foot of the Clarion hill from either Punxutawney, Ernest or DuBois, and the decapod engines have been ordered in anticipation of these track improvements, and are expected to handle a train of 4,000 tons up Clarion hill with a consolidation at the head. These locomotives were illustrated in this journal in April, 1907, page 132, and May, 1907, page 188. They have 24 x 28 in. cylinders, 52 in. drivers, 80 in. boiler carrying 210 lbs. of steam and a tractive effort of 55,350 lbs.

WHAT RAILROADS HAVE DONE.—Did you ever stop to think that Omaha, or even Denver, is to-day, thanks to this railroad service, nearer to New York City than Philadelphia was in 1764, when Benjamin Franklin amused himself for three and a half days knitting stockings in a stage coach while going from the Quaker City to New York to sail to the other side in connection with some diplomatic service at the Court of St. James.—*From Mr. Deems' presidential address, Master Mechanics' Association.*

HEAVY ELECTRIC TRACTION ON THE NEW YORK, NEW HAVEN AND HARTFORD RAILWAY.

By E. H. McHenry, Vice-President.

The Act of Legislature of May 7, 1903, of the State of New York, providing for the future regulation of the terminals and approaches thereto of the New York & Harlem Railroad in the City of New York, authorizes the New York Central & Hudson River Railroad Company and the New York, New Haven & Hartford Railroad Company, lessees of the New York & Harlem Railroad Company, "to run their trains by electricity, or by compressed air, or by any motive power other than steam which does not involve combustion in the motors themselves" through the tunnel and over the tracks more specifically described. The Act requires that the change of motive power be made on or before July 1, 1908, and provides a penalty of $500 per day on and after that date for failure to comply with its terms. As there was no available form of motive power other than electricity which met the conditions of the Act, it accordingly became necessary for the N. Y. C. & H. R. R. R. and the N. Y., N. H. & H. R. R. to provide suitable engines, power houses, and track equipment for electrically operating all trains between the Grand Central Station at Forty-second Street and the prescribed sub-limits within the limits of the City of New York.

The terminal tracks of the New York & Harlem Railroad, between the Grand Central Station and the junction point at Woodlawn, a distance of twelve miles, are jointly leased and operated by both the Central and New Haven companies. The zone of electric operation on the lines of the latter was further extended twenty-one miles, to Stamford, to include the greater number of its suburban trains.

This feature of joint operation more than all others restricted and narrowed the latitude of choice in the selection of a system of electric traction by the New Haven Company. The Central Company was first in the field, and having previously adopted a system based on the use of continuous current motors taking current from a third rail, it was obvious that no method inconsistent with such conditions was open to the New Haven Company, and it was thus practically confined to a choice between a continuous current low voltage system as adopted by the Central Company and a more recently perfected high tension single phase system. The first has been in general use for a number of years and, as installed by the Central Company, includes the generation of alternating current at 11,000 volts and 25 cycles, high tension transmission to substations located approximately five miles apart, at which points it is reduced and transformed by static and rotary transformers to low tension continuous current at 666 volts. This current is supplied to the engine contact shoes through a secondary system of distributing feeders and an inverted third rail of improved type. Continuity and regularity of operation are further insured by a large and most noteworthy installation of storage batteries in each substation.

The single phase system is the latest and most advanced step in the evolution of electric traction, and it was not until 1904 that the first commercial installation, on the Cincinnati and Indianapolis Traction Company, was operated. With this system, electric power may be generated, transmitted, and supplied directly to the electric locomotive, substantially at the initial frequency and voltage, without intermediate reductions or transformations of any kind. In effect it duplicates the simplicity of the local street railway operating with continuous currents supplied directly to the motors from the trolley line. It avoids all necessity for the ordinary equipment of static and rotary transformers, storage batteries, low tension switchboards, and low tension distributing and contact conductors, while affording the flexibility and economy of high tension A. C. transmission over long distances.

The single phase motor, as its name implies, operates with single phase currents, and its characteristics are essentially identical with those of the more familiar continuous current series motors. Single phase motors are adapted for operating with either alternating or continuous currents, and this valuable feature makes it possible to design locomotives which may be operated at will by high tension alternating currents from an overhead conductor, or low tension continuous currents from a third rail.

The New Haven Company was one of the earliest pioneers in the field of heavy electric traction, and has operated six of its shorter branch lines by electricity in commercial service for a number of years past, beginning as early as 1895. Three of these lines, aggregating thirty-three miles in length, were equipped for overhead contact, and the remaining lines, aggregating thirty-nine and one-half miles in length, for a third rail contact. All lines were operated with 500 volt continuous current motors, supplied from main stations and substations of the familiar type. The third rail was rather primitive in form and without protective devices of any sort. So many fatalities and injuries followed the use of this method of supplying current to the motors that the railroad company was compelled to abandon all third rail operation in Connecticut and revert to steam service, by a decree of the Superior Court dated June 13, 1906, and it now has no third rail in service excepting a junction overlap with the New York Central road at Woodlawn. Improved methods of protecting the third rail were available which would have considerably mitigated the more dangerous features of the earlier installations, but the unfortunate and unsatisfactory experience of the railroad company with this type of construction influenced its decision in favor of the single phase system, which was finally adopted after a careful and complete investigation of the relative merits and disadvantages of the two methods of construction.

Had the study of the question been limited to the equipment of the terminal section in New York City, considerations of uniformity and expediency would doubtless have influenced the decision in favor of continuous current motors, taking current from a third rail. The New Haven Company, however, recognized the great importance of its decision in its far-reaching effect upon future extensions of electric service to other parts of its system, and the final decision was based upon a study of the subject as a whole rather than upon the solution of the terminal problem only.

The distinguishing characteristic of electric traction as contrasted with that of steam driven locomotives is in the condition that the motive power is utilized at variable and varying distances from the point of generation, and the selection of a system of transmission best adapted to such conditions, which combines in greatest measure qualities of efficiency, flexibility, simplicity, and lowest first cost, is of paramount importance. A glance at the map shows that the New Haven system comprises a network of lines and indicates that its transmission problems must be worked out for areas rather than for linear distances, thus reversing ordinary conditions.

As the area served increases as the *square* of the radius of transmission from the generating center, and as there may be many circuits in the network which will serve as paths to common points of use, it is evident that ordinary methods of calculation will be greatly modified. Under such conditions the economic radius corresponding to any initial potential will be considerably extended, and the commercial and practical value of high potential transmission will be much increased.

While both methods under consideration included high tension transmission by alternating current, it was believed that the combination method requiring transforming devices and continuous current motors was less well adapted to the conditions than its simpler single phase competitor for many reasons. The electric efficiency of the combination system between power house busbars and engine shoes is 75 per cent. only, as compared with 95 per cent. for the single phase system. The flexibility of the former is impaired by the limited radius of the secondary low tension distribution, requiring substations at frequent intervals, and still further by the limitations imposed by the use of a third or conductor rail. The position and height of this rail in its proper relation to the track rail must be rigidly maintained, and the practical margin of permissible variation is measured in fractions of an inch. Also, its continuity is broken at switches and crossings by frequent transferrence of the conductor rail to

the opposite side of the track or to an overhead position. In contrast, the single phase system requires no substations or secondary circuits; the continuity of the overhead conductor is complete, and its position and height may vary within vertical and horizontal limits of eight feet and four feet, respectively, without losing contact with the collecting shoes on the pantagraph frames.

It is yet too early to furnish definite and positive comparisons of cost of the two methods under consideration, but the calculations and experience of the railroad company's engineers indicate that the total cost of a single phase installation will be much less than that of the continuous current system, and that the higher electrical efficiency, lower fixed charges, maintenance, and operating expenses of the single phase system all tend to reduce the relative cost of current delivered to the engine shoes in about the same proportion.

The determination of the most economical and desirable frequency and voltage of the transmission system involved the consideration of many factors entering into the problem. The choice of frequency was practically fixed by the manufacturing companies within limits of fifteen and twenty-five cycles, and the comparative merits of these two rates only were considered.

The lower frequency afforded a material reduction in weight, size and cost of motors, a reduction in conductor losses and induction disturbances, together with an increase in the power factor of the motors. Per contra, its adoption would have materially impaired the commercial value of the system as a whole, in restricting or preventing its extension for many other uses incidental to railway operation. The standard power and railway frequency in general use is twenty-five cycles, and as the New Haven Company already owned a number of power houses generating current at this frequency for standard trolley operation, and, in addition, had equipped many of its shops with twenty-five cycle motors, the adoption of fifteen cycles would have required the abandonment of a large amount of standard apparatus, or the interposition of costly and inefficient means of translation. The lighting of stations and other buildings was quite an important factor, as 25 cycles is the lowest frequency at which the carbon filament lamps in general use can be satisfactorily operated. It was also considered desirable to provide for operation in parallel with the 25 cycle generators already adopted by the New York Central Company. The practical effect of a change from 25 to 15 cycle apparatus was thus substantially equivalent to a "break in gauge," and under existing conditions it was decided that the practical commercial value of the higher frequency outweighed the more theoretical merits of the lower one.

Various alternatives were considered before fixing the generating and transmission *e. m. f.* of the system. It was at first proposed to increase the economical radius of transmission to the utmost by generating current at the highest initial voltage for which generators could be safely designed (about 22,000 volts) and to provide substations at suitable intervals, equipped with static transformers, for supplying current at 3,000-6,000 volts to secondary contact circuits. As the two motors in each electric locomotive truck are permanently connected in series, current must be supplied at 560 volts through the transformer forming a part of the locomotive's equipment.

It became evident, however, that a great gain in simplicity would result if the intermediate substations and line transformers could be cut out altogether, and further study demonstrated the possibility of effecting this by reducing the initial *e. m. f.* to 11,000 volts and raising the ratio of the locomotive transformer to correspond. This was carried into effect with a resulting reduction in capital and operating cost, coupled with an increase of electrical efficiency, which proved most gratifying. Incidentally, the difficulties in designing satisfactory collecting devices were greatly diminished.

The difficult and responsible task of determining and analyzing operating conditions and requirements was assigned to Mr. Calvert Townley, consulting engineer, and Mr. William S. Murray, electrical engineer, of the New Haven Company, to whom, together with their able assistants, credit is due for the design, supervision and successful execution of the many and difficult details of this novel installation.

The Commercial Aspect.

A few comments upon the commercial aspects of electric traction may not prove uninteresting, as the natural prejudice of the stockholder, in favor of the continued maintenance of dividends must be respected, and the technical expert too frequently neglects this aspect in his scientific ardor for the building of monuments of engineering skill and achievement.

Numerous analyses and comparisons of the comparative costs of electric and steam operation have been published from time to time, which tend to prove that a considerable saving in fuel, engine repairs and other operating expenses may be expected. Under favorable conditions this saving may be large enough to pay interest and other fixed charges upon the additional construction investment and still leave a satisfactory margin to apply on dividends. Under general conditions, however, it is altogether improbable that the direct saving resulting from the simple substitution of electric for steam power will be sufficient to justify the additional investment and financial risk.

In changing the method of motive power on existing railways, the conditions are by no means so simple as in the construction of new lines, as in the former case a great amount of capital already invested must be sacrificed, and the problems of adaptation to existing conditions are peculiarly severe. In particular, the transition stage in bridging over the gap between steam and electric operation is both expensive and difficult, as the change affects train lighting and heating, telegraph and telephone service, signaling, and track maintenance, for which both temporary and permanent provision must be made. The simultaneous maintenance of facilities and working forces for both steam and electric service within the same limits will be rarely profitable, for the reason that a large proportion of expenses incident to both kinds of service is retained without realizing the full economy of either.

To secure the fullest economy it is necessary to at least extend the new service over the whole length of the existing engine stage or district, and to include both passenger and freight trains, and in this connection it is interesting to note that in the case of the New Haven Company the passenger train mileage forms so large a proportion of the whole that no additional generating and transmission capacity will be needed when electric traction is extended to freight service.

The application of electric traction to heavy railway service will probably be governed by other and more important considerations than its mere relative cost as a motive power under similar conditions, as illustrated in the development of the ordinary trolley service. In this development the commercial value of higher speeds and of increased car capacity is so large that the relative cost of electric versus animal tractive power becomes almost negligible by comparison. Analogous results may be hoped for in the corresponding development of electric traction in heavy railway service, as the new conditions will afford opportunities for at least two radical modifications of existing conditions, quite apart from minor economies.

In steam service the weight and speed of trains are limited by the horse power capacity of the locomotive, which generates its own power, and there are but few locomotives which can generate sufficient steam to utilize their full cylinder tractive power at speeds in excess of twelve miles an hour. Consequently, any increase of speed beyond certain limits can only be attained by sacrificing train tonnage in a corresponding degree. The division of the train mile cost by the lesser number of tons increases the ton mile cost proportionately.

The high cost of fast freight service is principally due to this effect of a diminishing divisor, while it would seem that electric traction should permit high speeds without sacrificing commercial tonnage, as, with a relatively unlimited source of power at command, the maximum drawbar pull permitted by the motor design, may be maintained at all speeds.

The commercial value of high speed in freight and passenger

service is so great that the prospect of escaping the present penalties accompanying reduced train capacity becomes doubly interesting.

Hardly less important is the opportunity afforded at the opposite end of the scale, for the economical operation of trains of *minimum* capacity. The train capacity cannot be reduced without loss, below the point where the earnings equal the train mile cost, and if this cost cannot be reduced proportionately with reduced capacity, the inferior limit of capacity may be uneconomically large. In steam service the irreducible elements entering into the train mile cost are so large that it is rarely profitable to operate trains earning less than forty to fifty cents per mile. In contrast, electric service permits an extreme reduction of the train length to single car units, costing to operate but ten to fifteen cents per car mile. Hence, the frequency of service may be increased and rates reduced, which in turn will react upon the volume of traffic, with the final result of increasing both gross and net earnings. It may, therefore, be claimed for electric traction that it will extend the limits of profitable operation of high speed heavy trains, and also of light trains of low capacity.

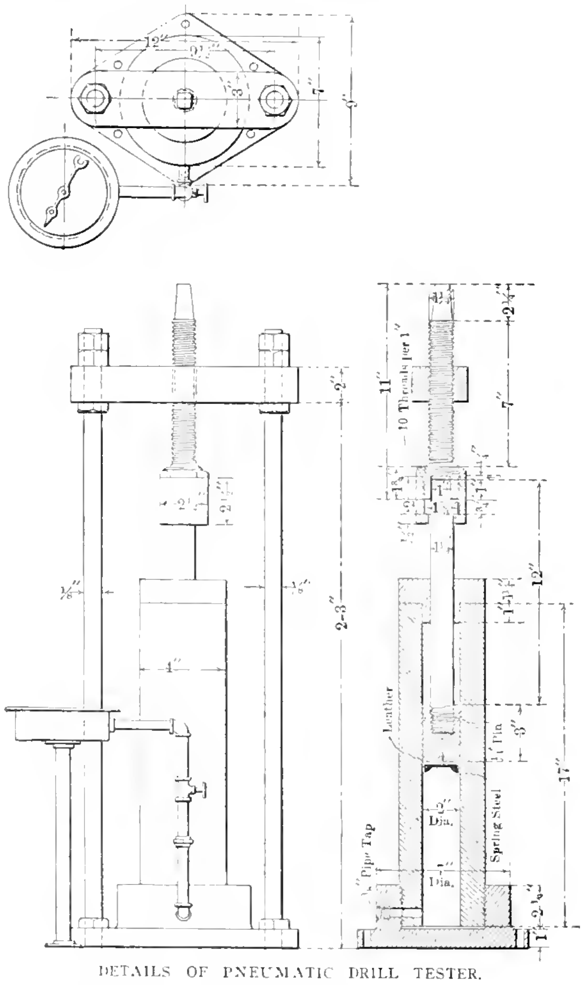
Other but relatively minor advantages are possible in the effect upon earnings, due to the elimination of smoke, gases, dust, cinders, and heat, the better ventilation of cars, the extension of electric train lighting and heating; and of the effect upon expenses due to the concentration of power production in large and economical power houses, a reduction of engine repairs, an increase of effective engine and train mileage, a more or less complete elimination of engine houses, turntables, fuel stations, water tanks, cinder pits, and other operating facilities, the consolidation of power requirements for traction, pumping, operating shops, elevators, and general uses, and the use of current for lighting switch lamps, stations and other buildings.

Finally, the availability and value of real estate and structures at large terminals will be greatly augmented by the possibilities of using two or more superimposed track levels, as strikingly exemplified in the plans for new terminals in New York City for the New York Central and the Pennsylvania Companies.

A general change from steam to electricity will render unproductive a very large amount of invested capital, and create the necessity for the expenditure of additional amounts still greater, but there is no reason to doubt that the transition already in progress will be rapidly extended and applied at all points where congested terminals, high frequency of train service and low cost of power create favorable conditions.

PNEUMATIC DRILL TESTER.

A unique pneumatic drill tester is in use in the tool room of the McKees Rocks shops of the Pittsburgh & Lake Erie Railroad. The drawing shows the construction of this device and the photograph shows it with a drill in position for making a test. The cylinder is 2 ins. in diameter, and is partially filled with oil. The pneumatic drill drives the screw, which forces the piston in

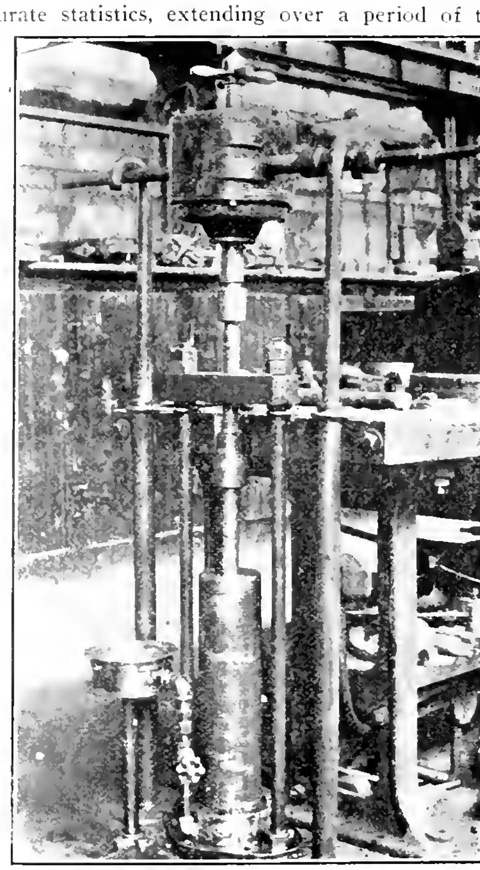


DETAILS OF PNEUMATIC DRILL TESTER.

the cylinder downward. The recording gauge, which has a capacity of 6000 lbs., records the pressure in the cylinder and the capacity of the drill is determined by the pressure at which it is stalled. Different makes of drills, guaranteed to be of the same power, have shown a variation on this test of from 1800 to 5500 pounds.

When a new drill is received at the shop it is tested and a record made of its capacity. When the drill requires repairs or any complaint is made as to its not doing the work properly, it is tested to determine whether its capacity has fallen off, and after it is repaired it is again tested to make sure it has been restored to its original capacity.

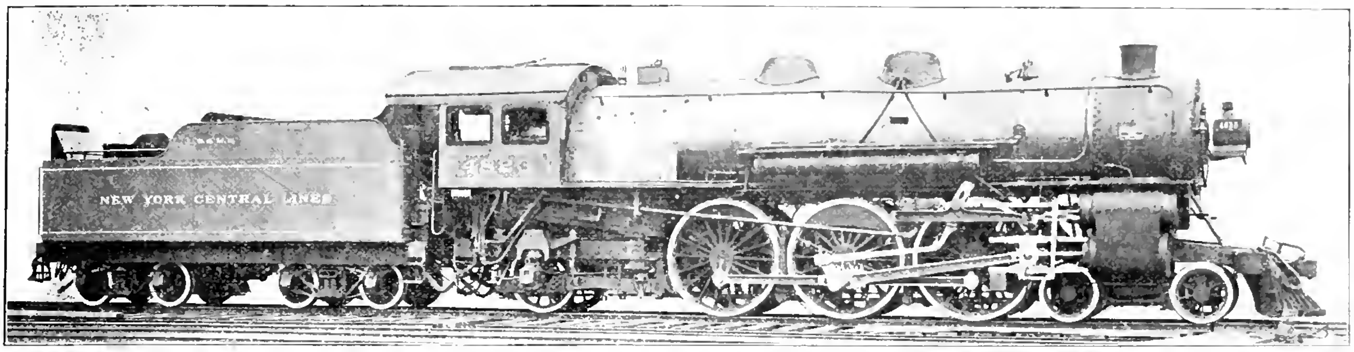
Fuel Consumption of Gasoline Motor Cars.—Mr. W. R. McKeen, Jr., in a communication to *The Railroad Gazette*, states that accurate statistics, extending over a period of two years,



PNEUMATIC DRILL TESTER IN OPERATION.

show that the Union Pacific motor cars are being operated at a cost of $3.36 per 100 miles for fuel.

Motor Driven Machine Tools.—It is said that 70 per cent. of the output of machine tools by the Niles-Bement-Pond Company are driven by individual motors, and that the same condition obtains for 50 per cent. of the products handled by Manning, Maxwell & Moore.—*Power*.



PACIFIC TYPE PASSENGER LOCOMOTIVE.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

The Prairie type locomotive for passenger service has found its most extensive and general use on the Lake Shore & Michigan Southern Railway, where for the past six years it has been the favorite type for heavy high speed trains. The first locomotive of this type was introduced on that railroad in 1901, and weighed 174,500 lbs. This was followed three years later by a new design of the same type, which weighed 233,000 lbs., and at that time was the heaviest passenger locomotive in the world. In 1906 another design was brought out, which weighed 244,700 lbs., again being the heaviest passenger locomotive in the world. The next step in this development of passenger locomotives on this railway changes from the Prairie to the Pacific type, which are now being delivered by the American Locomotive Company. This step was taken to conform to the New York Central Lines standards. The standard modern passenger engine of that system at the present time is the 21 x 26 in. Atlantic type and the Pacific type is, in its wheel arrangement, simply an enlargement of the Atlantic type. These locomotives have the distinction of being next to the heaviest ever built ,being exceeded only by the one recently built for the Pennsylvania Railroad, which was illustrated on page 267 of the July issue of this journal.

The accompanying table traces the passenger locomotive development on this railway through the five different designs from the 10-wheel type used in 1899 to this last order, which includes

DEVELOPMENT OF PASSENGER LOCOMOTIVES, L. S. & M. S. RY.

Type	4-6-0	2-6-2	2-6-2	2-6-2	4-6-2
Year built	1899	1901	1904	1906	1907
Total weight, lbs.	171,800	174.500	233,000	244,700	261 500
Weight on drivers, lbs.	133,000	130,000	166,000	170,000	170,700
Tractive effort, lbs.	24,990	25,200	27,850	27,850	29,200
Size cylinders	20″ × 28″	20½″ × 28″	21½″ × 28″	21½″ × 28″	22″ × 28″
Steam pressure, lbs.	210	200	200	200	200
Diam. drivers	80″	80″	79″	79″	79″
Total heat. surf., sq. ft.	2917.	3343.	3905.	3905.	4195.
Tube heat. surf., sq. ft.	2694.	3169.	3678.	3678.	3961.
No. and diam. of tubes.	345-2	285-2¼	322-2¼	322-2¼	379-2
Length of tubes	15′ ¼″	19′	19′ 6″	19′ 6″	20′
Grate area, sq. ft.	33.6	48.5	55.	55.	56.3
Diameter of boiler	66″	66″	70″	70″	72″
Total wgt. ÷ total H S	59.5	52.3	59.8	62.5	62.2
Wt. drivers ÷ total H. S.	45.6	39.0	42.5	43.6	40.8
Total H. S. ÷ grate area	87.0	68.8	71.0	71.0	74.3
B. D. factor	684.	605.	563.	563.	550.
Total H. S. ÷ vol. of cyls.	286.	314.	332.	332.	345.
Refer in AMER. ENG.	'99-344	'01-71	'04-413	'06-203	

25 locomotives. The most noticeable feature in this comparison is the large increase of boiler capacity, the B. D. factor having steadily decreased from 648 to 550. The cylinders at the same time have increased from 20 x 28 to 22 x 28 in., the steam pressure and size of drivers meanwhile remaining practically the same. It will be noticed that the Pacific type engines have but little more weight on drivers than the latest design of Prairie type, although the cylinder is ½ in. larger in diameter and the tractive effort correspondingly increased. The factor of adhesion, however, is ample. The introduction of the four-wheel truck has permitted the installing of a heavier boiler without increasing the weight on drivers and at the same time giving the advantage of the better guiding qualities of this type of truck without reducing the pulling power of the locomotive.

These locomotives are very similar to the one built for the Pennsylvania Railroad, mentioned above. They employ the same general arrangement of Walschaert valve gear, in which the link is hung on a steel casting supported outside the front driving wheel; also the same design and arrangement of radial trailer truck.

The boilers are of the radial stay type with conical connection sheet, the outside diameter of the front ring being 72 in. Three of the boilers are fitted with combustion chambers, and in these the front tube sheet has been moved ahead sufficient to give a length of tubes of 18 ft. or only 2 ft. shorter than the tubes in the engines without combustion chambers. The chamber itself is 4 ft. long. The boilers without combustion chambers contain 379-2 in. tubes, and those with combustion chambers 332-2 in. tubes. While this decreases the amount of total heating surface considerably it is believed from the experience of the Northern Pacific Railway that the capacity of the boiler will not be materially decreased by the installation of the combustion chamber. The chamber is radially stayed to the shell on the bottom and sides, and has expansion stays on the upper section. Ample water space of 8½ in. at the bottom and 7 in. at the closest point at the sides is provided. The smaller number of flues in the boilers with the combustion chambers is due to the fact that the outer shell of all the boilers is alike, so that when new fireboxes are required combustion chambers can either be applied or removed. On the previous order of Prairie type locomotive 2¼ in. tubes were specified, but it was found that better service could be obtaned from 2 in. tubes without detriment to the steaming qualities of the boiler, and this size has therefore been used on the new engines.

The locomotives are furnished with 79 in. wheels, but the machinery parts are arranged so that 69 in. wheels may be applied where it is required to operate over divisions having considerable grade. The cylinders are designed, so that when 69 in. wheels are used they can bored to 24 in.

The general dimensions, weights and ratios of both designs of locomotives are given in the table below:

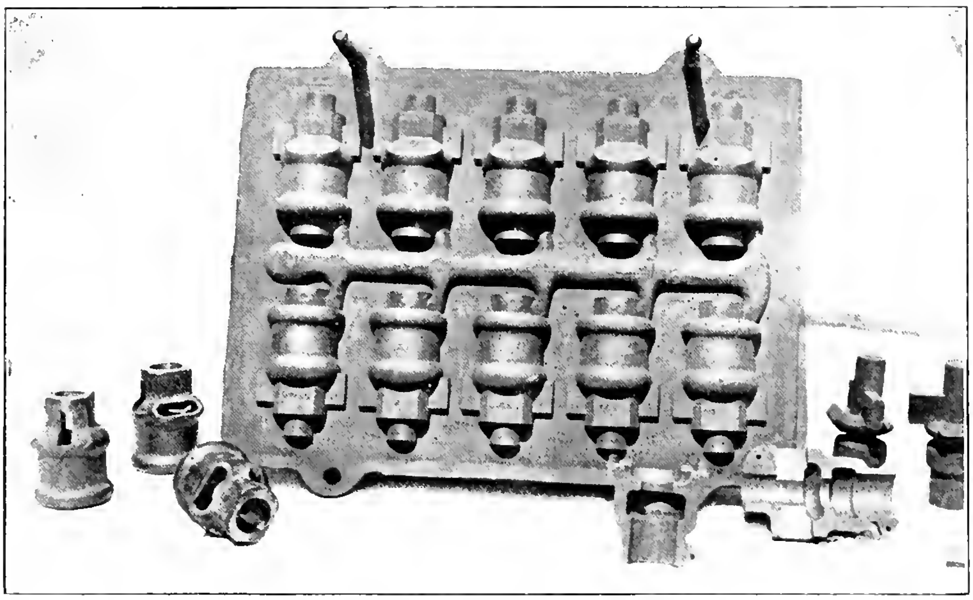
GENERAL DATA.

	Without Comb. Chamber.	With Comb. Chamber.
Service	Passenger	Passenger
Fuel	Bit. Coal	Bit. Coal
Tractive effort	29,200 lbs.	29,200 lbs.
Weight in working order	261,500 lbs.	261,500 lbs.
Weight on drivers	170,700 lbs.	167,000 lbs.
Weight of engine and tender in working order	423,700 lbs.	423,700 lbs.
Wheel base, driving	14 ft.	14 ft.
Wheel base, total	36 ft. 6 in.	36 ft. 6 in.
Wheel base, engine and tender	67 ft. 10¼ in.	67 ft 10¼ in.
RATIOS		
Weight on drivers ÷ tractive effort	5.83	5.72
Total weight ÷ tractive effort	9.03	9.03
Tractive effort × diam. drivers ÷ heating surface	550.00	675.00
Total heating surface ÷ grate area	74.50	60.50
Firebox heat. surface ÷ total heat. surface, per cent	4.92	8.62
Weight on drivers ÷ total heating surface	40.60	48.90
Total weight ÷ total heating surface	62.40	76.70
Volume both cylinders, cu. ft.	12.35	12.35
Total heating surface ÷ vol. cylinders	340.00	276.00
Grate area ÷ vol. cylinders	4.58	4.58
CYLINDERS.		
Kind	Simple	Simple
Diameter and stroke	22 in. × 28 in.	22 × 28 in.
VALVES.		
Kind	Piston	Piston
Greatest travel	6 in.	6 in.
Outside lap	1 1/16 in.	1 1/16 in.
Inside clearance	1/16 in.	1/16 in.
Lead in full gear	¼ in.	¼ in.
WHEELS.		
Driving, diameter over tires	79 in.	79 in.
Driving, thickness of tires	72 in.	72 in.
Driving journals, main, diameter and length	10½ × 12 in.	10½ × 12 in.
Driving journals, others, diam. and length	10½ × 12 in.	10½ × 12 in.

Engine truck wheels, diameter	36 in.	36 in.
Engine truck, journals	6½ × 12 in.	6½ × 12 in.
Trailing truck wheels, diameter	50¼ in.	50¼ in.
Trailing truck, journals	8 × 14 in.	8 × 14 in.
BOILER		
Style	Conical	Conical
Working pressure	200 lbs.	200 lbs.
Outside diameter of first ring	71 15/16 in.	71 15/16 in.
Firebox, length and width	108½ × 75¼ in.	108½ × 75¼ in.
Firebox plates, thickness	⅜ and ½ in.	⅜ and ½ in.
Firebox, water space	4½ in.	4½ in.
Tubes, number and outside diam.	379—2 in.	332—2 in.
Tubes, length	20 ft.	18 ft.
Heating surface, tubes	3,960.6 sq. ft.	3,112.5 sq. ft.
Heating surface, firebox	206.0 sq. ft.	268.4 sq. ft.
Heating surface, total	1,195.0 sq. ft.	3,409.3 sq. ft.
Grate area	56.3 sq. ft.	56.3 sq. ft.
Smokestack, diameter	18 and 20 in.	18 and 20 in.
Smokestack, height above rail	14 ft. 7⅞ in.	14 ft. 7⅞ in.
TENDER.		
Tank	Water Bottom	——
Frame	13 in. Chan.	13 in. Chan.
Wheels, diameter	36 in.	36 in.
Journals, diameter and length	5½ × 10 in.	5½ × 10 in.
Water capacity	8,000 gals.	8,000 gals.
Coal capacity	14 tons	14 tons

A GOOD IDEA IN PATTERN MAKING.

The method of moulding the standard Lake Shore cylinder cocks at the Collinwood shops is worthy of note. The pattern is mounted on one side of the plate only, as shown in the illustration, but is so arranged that the drag and cope of the flask are rammed from the same plate without changing. This idea is in very general use in connection with the patterns for the brass foundry at the Collinwood shops and simplifies the matter of pattern making and moulding so much that it is surprising that it is not followed to a greater extent in other shops, as it has a very wide range of application. The pattern shown is used in connection with a Berkshire moulding machine. The core box and cores are shown to the right and the finished casting to the left, in the illustration.



PATTERN FOR MOULDING CYLINDER COCKS.

SIDE DOOR SUBURBAN PASSENGER CARS.

In a report on transit facilities prepared by the City Club of New York and addressed to the Public Service Commission the Illinois Central type of side door car is discussed as follows:

"The Illinois Central Railroad, with the heaviest suburban traffic in this country, operates cars of 100 seats, with 12 doors on each side. The seats face one another in pairs, and a door is placed between each pair of seats. The maximum stopping time of a train composed of these cars is conditioned only by the time that it requires eight people to pass out and eight to enter, eight being the number served by one door. In practical operation these trains stop on an average but 7.07 seconds. Owing to the fact that the guard who closes all the doors of a car stands at one side of the car, so that he can look along the whole length of both the outside and inside of the car, very few accidents occur. Mr. W. D. Dunning, an official of the road, made the following statement in a letter written to the secretary of the City Club:

"'The side-door cars have been in daily use since 1903, and during the three years of their service under my direct charge and as a result of my intimate experience with these cars, I can unhesitatingly say they are a success in every phase of the service in which they are used, and I believe they fully meet every requirement of a dense passenger traffic under conditions where quickness of operation is an essential requisite. The cars each seat 100 passengers, and have standing room for a large number in addition, without interfering with rapid entrance and exit. No difficulties have been found in their operation, the perfect control of the side doors by the trainmen preventing passengers from getting on or off the cars while in motion. The doors work freely, with but little effort, and no trouble has been experienced in keeping the cars warm during the coldest weather. The time saved in their use, over the end-door type, is more noticeable during the hours of heavy travel, and has resulted in the average stop being reduced from 30 seconds to 7 seconds. All of the side-door cars are framed throughout of steel and were built new at the company's shops. None of the old cars were reconstructed. No platform men are required with the side-door cars, the doors being operated from within the cars by the regular trainmen. As to the accidents to passengers with the side-door cars, I have consulted with our claim department officials, and the conclusion is reached that the use of the side doors has reduced the number of accidents about 90 per cent. In fact, with the exception of an occasional slight mishap, the element of personal injury has been well nigh eliminated.'"

To use this type of car in the New York Subway some special provision will have to be made for stations on curves, but this can undoubtedly be taken care of. It is estimated that the introduction of this type of car would increase the total possible seating capacity per hour of the Subway, during rush hours, from 18,876 to 56,000.

TRAFFIC IN NEW YORK CITY.—The total number of passengers handled by the elevated, surface and subway lines of New York, in round numbers, was 670,000,000 in 1902, 765,000,000 in 1903, 814,000,000 in 1904, 816,000,000 in 1905, and 1,007,000,000 in 1906. The increase in 1906 over 1905 was 146,200,000, or 14 per cent., which is the greatest gain recorded both in volume and percentage.

DEVELOPMENT OF OCEAN LINERS.—The accompany table, taken from *Engineering* (London) for August 2nd, and presented in connection with a very complete detail description of the Cunard turbine-driven quadruple-screw Atlantic liner Lusitania, presents in a compact form the development in capacity and efficiency of ocean liners since the advent of the first Cunard liner.

	"Britannia," 1840.	"Persia," 1856.	"Gallia," 1879.	"Umbria," 1884.	"Campania," 1893.	"Lusitania," 1907.
Coal necessary to steam to New York .. tons	570	1400	836	1,900	2,900	5,000 *
Cargo carried .. "	224	750	1700	1,000	1,620	1,500
Passengers	115	250	320	1,225	1,700	2,198
Indicated horse-power	710	3600	5000	14,500	30,000	68,000
Steam Pressure .. lbs	9	33	75	100	165	200
Coal per indicated horse-power per hour .. lbs	5.1	3.8	1.9	1.9	1.6	1.45 *
Speed .. knots	8.5	13.1	15.5	19	22	25

* Estimated.

THE MAXIMUS BRAKE.

It is well known that the coefficient of friction between the brake shoe and the wheel, and hence the retarding effect of the brake, is very materially less at high speeds than it is just before the wheel comes to rest. This condition caused the adoption in this country several years ago of the high speed brake for heavy passenger trains, which, by increasing the pressure in the brake cylinder upon the application of the brake and gradually reducing it by allowing the excess to leak off through a reducing valve, the final pressure being the same as for the ordinary quick action brake, has resulted in decreasing the length of stop about 30 per cent. from speeds of 50 miles per hour and upwards.

The change from the quick action to the high speed brake requires no alteration, other than some strengthening, in the foundation brake gear. There is in use, however, in England and on the Continent an arrangement of the foundation brake gear which automatically performs the same functions as the high speed brake with the further advantage that it also automatically adjusts the intensity of its action to the speed at which the train is running when the brake is applied. This brake is known as the Maximus and the results of some tests recently made on the North-Eastern Railway of England are shown by the curves in one of the illustrations. These tests represent stops made from different speeds with a single coach, braked on four of its six wheels to 62 per cent. of its weight with the ordinary brake. The tests were made with the same coach on the same line under similar conditions and indicate very clearly the advantage of the Maximus brake over the ordinary for high speed trains.

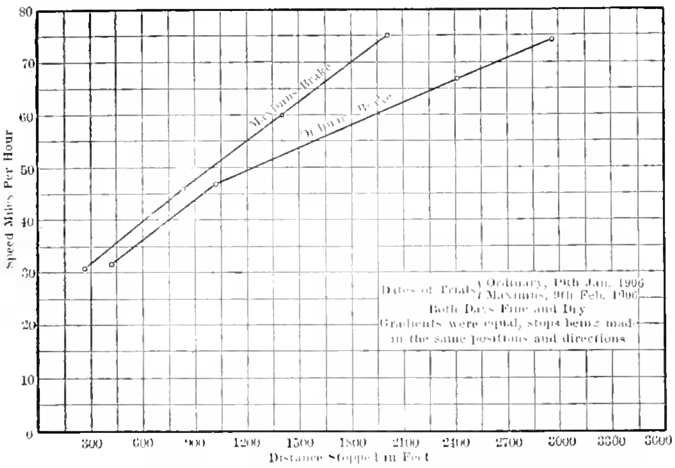
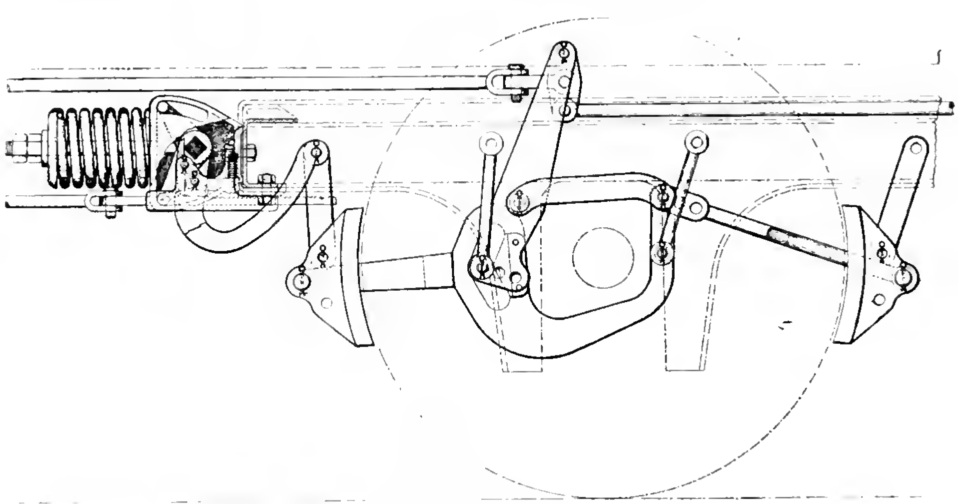


DIAGRAM OF BRAKE TRIALS ON THE NORTH-EASTERN RAILWAY.

The arrangement of the device is shown in the illustrations, and while it is here illustrated as including two brake shoes, the principles are equally applicable where one brake shoe is used. The shoe is suspended by a link hung from a bell crank which is rigidly fastened to a square rod reaching across the end of the truck. To this shaft are also fastened two short lever arms, which have pins at the end fitting in radial slots in the casting bolted to the end piece of the truck. This casting also forms a seat for a spiral spring, the stem of which is attached to the square shaft. At the center of the shaft and fastened to the truck frame is a fitting which supports a ratchet slide having a pivoted tooth pawl held in the disengaged position by the shaft when the brake shoe is in its normal position on the wheel. The ratchet slide is connected by a rod to the end of the cylinder or floating lever and the teeth are arranged to permit the brake to be released, but will prevent any further application after the pawl is dropped into place. The connection between the truck lever and the brake beam is made through a roller on the lever which works in a V-shaped cam slot in the yoke connecting to the brake beam.



MAXIMUS BRAKE APPLIED TO A FOUR-WHEEL TRUCK.

The action of the brake is as follows: The coil spring is tightened up, by means of a follower plate and nuts on the end of its stem, to give a tension which will hold the brake shoe in its normal position under a certain predetermined coefficient of friction.

By means of a larger cylinder, higher pressure, or change in leverage, the brakes being applied at high speed are given a brake shoe pressure which equals 160 per cent. of the weight of the cars. At high speeds this will not produce a coefficient of friction sufficiently great to overcome the resistance of the spring and hence the apparatus remains in its normal position. When the speed of the train is sufficiently slackened to increase the coefficient of friction then the action of the brake shoe pulling on the bell crank compresses the spring, slightly moves the square shaft inward and downward (or upward), thus releasing the pawl, which engages the ratchet slide and prevents the cylinder pressure from following up the shoe. As this takes place the shoe in moving downward alters the position of the roller on the truck lever in the V-shaped slot, so as to move the shoe away from the wheel and thus reduce the pressure. In this manner the shoe maintains a position on the wheel that corresponds to the coefficient of friction for which the coil springs are originally set, since a reduction in the friction will permit the spring to again raise the shoe and draw it tighter against the wheel by the change in the connection to the truck lever.

This apparatus is controlled by the Maximus Brake Syndicate, Queen Ann's Chambers, Westminster, London, and is being introduced in this country by Mr. Harvey E. Brown, managing director of the company, whose headquarters at present are at the Southern Hotel, St. Louis, Mo.

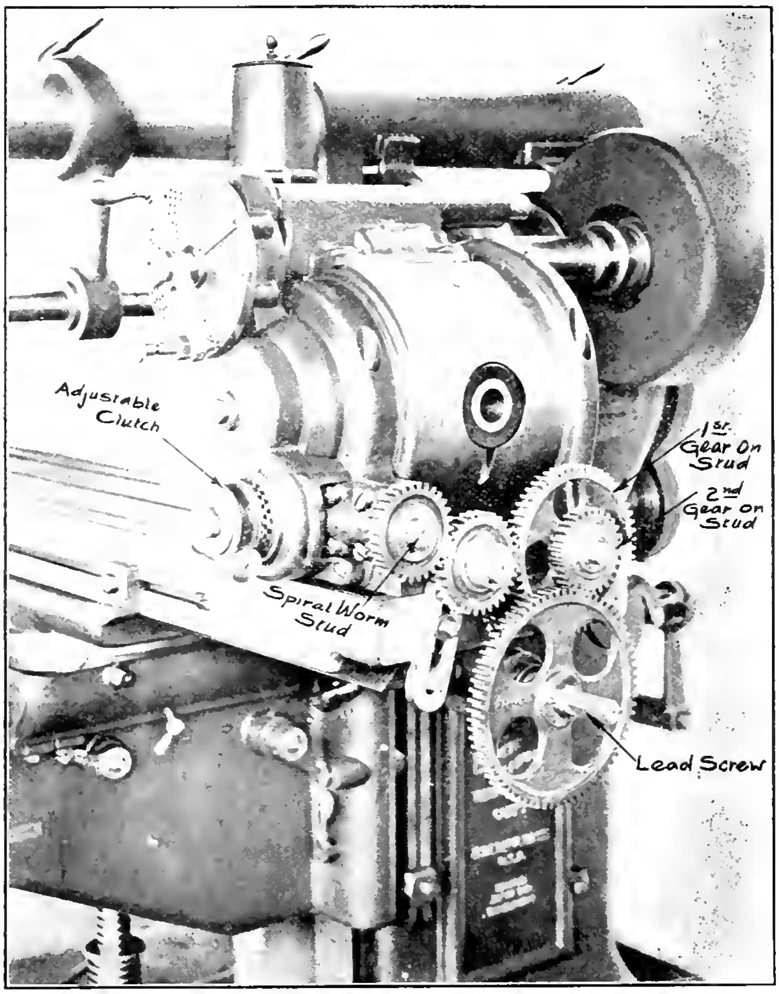
COST OF BLOCK SIGNALS.—Some idea of the enormous cost of equipping a railroad with block signals may be gained from reports just compiled by the Pennsylvania Railroad. Out of a total mileage on the Company's Eastern Lines of 6,032, more than fifteen hundred additional miles have within the last three years been equipped with block signals, at a cost of $856,520.36 to the railroad company, and adding $210,816.05 to the annual operating expenses. The report shows that the Pennsylvania Company now has every mile of its main lines protected by block signals, and of the entire mileage of the Lines East but about 500 miles are not so equipped; most of this, however, consists of short, industrial lines or branch lines on which the traffic is so light and of such a character as to render the block signal unnecessary.

During 1906 there were 86 old locomotives sold and 43 scrapped on the Pennsylvania Railroad proper.

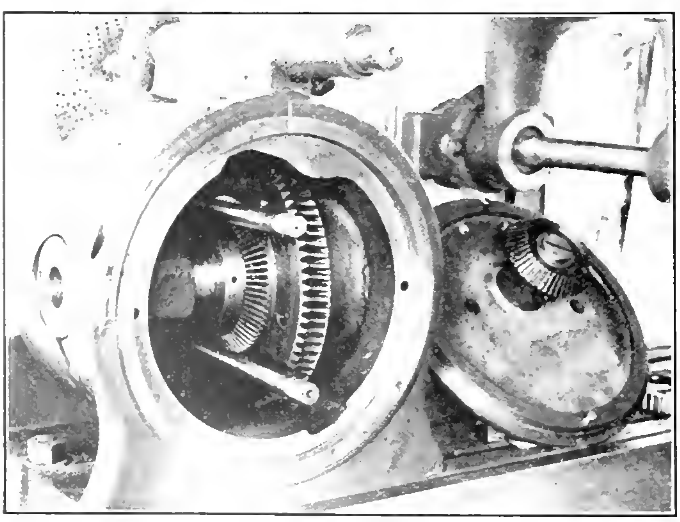
NEW UNIVERSAL INDEX AND SPIRAL HEAD FOR MILLING MACHINES.

A new universal index and spiral head has been designed by the Becker-Brainard Milling Machine Company, of Hyde Park, Mass., to meet the need of a spiral head that will answer the requirements of the heavier duty now imposed on milling machines and still retain the accuracy and at the same time meet the requirements of the wide range of work met with in ordinary practice, without sacrificing any of the desirable features of the older heads, and to add such features as will increase the usefulness of the head in general work. The accompanying illustrations show the various features of this new design. The increase in the strength of the head has not interfered with the ease of handling, nor made the head at all clumsy or awkward to operate. The design is of an approved type, having the swivel block housed between heavy uprights in which the block swings in a vertical plane. The block is held in any position by means of clamping bolts which draw the outside plates securely against the uprights, holding the head in position against the heaviest cuts.

The worm gear is made in two sections to insure accuracy in the hobbing of the teeth and in the adjusting for wear. An important feature of the design is the fact that the worm gear has been made as large as the swing of the different size heads will allow. The view showing the back head removed gives a good idea of the comparatively large diameter of the dividing wheel. This not only adds materially to the life of the wheel, but insures greater accuracy in the work than is possible with a smaller diameter, such as is ordinarily used. The large diameter and the coarse pitch of the teeth makes it possible to take heavier spiral cuts without any risk of impairing the accuracy or of distorting the teeth in the gear. The increase in the strength of the head throughout makes it possible to take heavier cuts at faster feeds and speeds and thus to utilize the high speed steels to greater advantage.

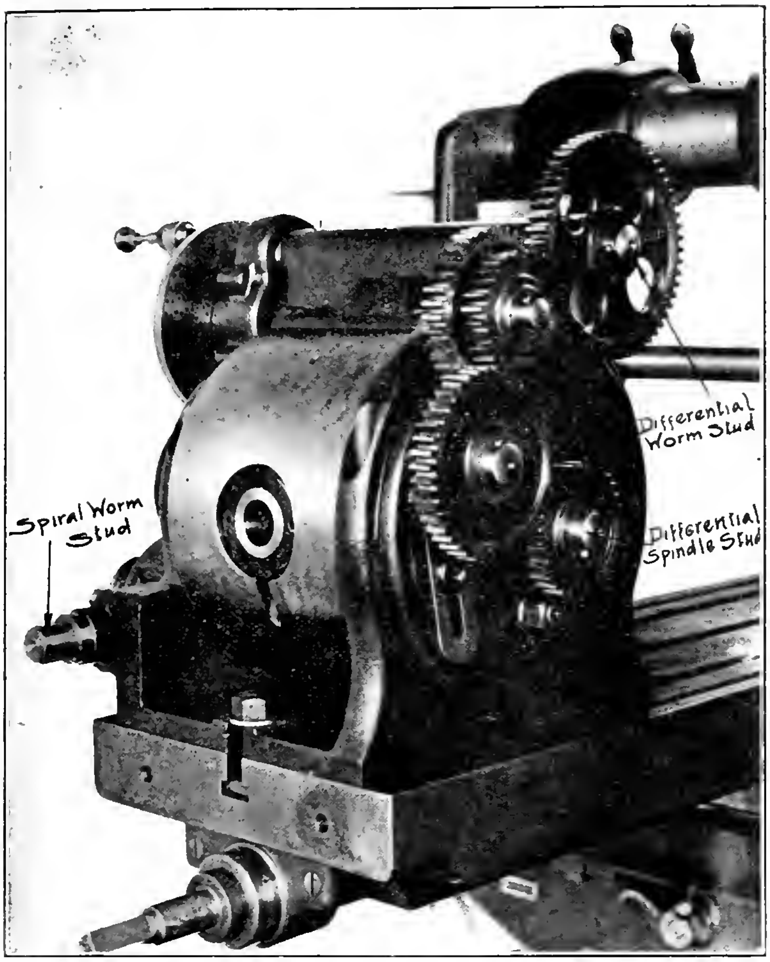


The idea of making the differential mechanism a component part of the head has been carried out so that the head may be used as an index or dividing head in any position along the platen, with the spindle either parallel with or at right angles to the main spindle of the machine, or in any intermediate position. This has been accomplished by placing the change gears, used in differential indexing, on the rear side of the head, as shown in the view where the gears are set in position. The gears have no connection with the table. With the gears used in differential indexing arranged on the head, it is possible to swing the spindle into position for cutting bevel gears or teeth on any conical work. This at once broadens the scope of differential indexing from cylindrical work to that which requires the angular setting of the spindle in the vertical plane.


SHOWING COMPARATIVE SIZE OF WORM WHEEL.

In order that the application of the differential indexing may be universal, it is necessary that it be made available for use on work with helical or spiral grooves, such as spiral gears. This has been accomplished in the following manner: The principle, on which the differential system of indexing works, makes it necessary to have the spindle and index plate so connected by means of change gearing that the movement of the spindle will cause a movement of the index plate in one direction or the other, as the case may be. This makes it necessary for the index plate to be free to move on its axis, independent of the index crank during the indexing operation. In cutting spirals the plate is geared to the lead screw by suitable change gears. The connection between the lead screw and the index plate must be broken when making division, in order that the index plate may be free to make the differential movement with the index crank. This breaking of the connection is accomplished by means of an adjustable clutch which is withdrawn during the indexing operation. After the division has been made, the teeth in the clutch will be found to be in such a position, in relation to the corresponding spaces, that it is impossible to engage them. In order to bring the teeth and spaces opposite each other, one-half of the clutch is made adjustable so that it may be rotated the required amount to bring the two portions in proper position for engagement. This adjustment is accomplished by means of the knurled knobs attached to the clutch. The connection between the index crank through the worm, worm gear, spindle and change gears of the differential indexing mechanism and the index plate, when the index pin is in mesh with a hole in the plate, would form a locked train, which must be released during the spiral cutting operation. This release is accomplished by means of the knurled knob back of the index plate, which operates a friction clutch.

Frequently it is desired to roll the work a small amount on its axis without shifting the dog or losing the position of the index pin, or the amount of roll over may be such that, should

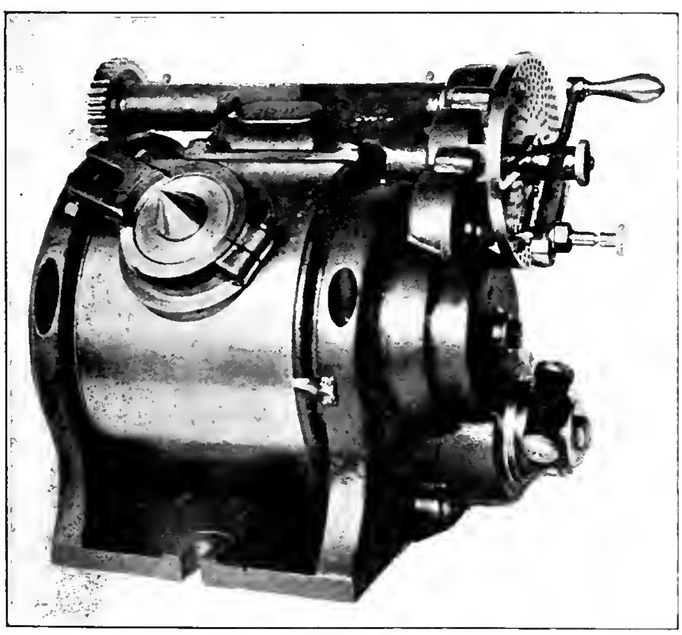


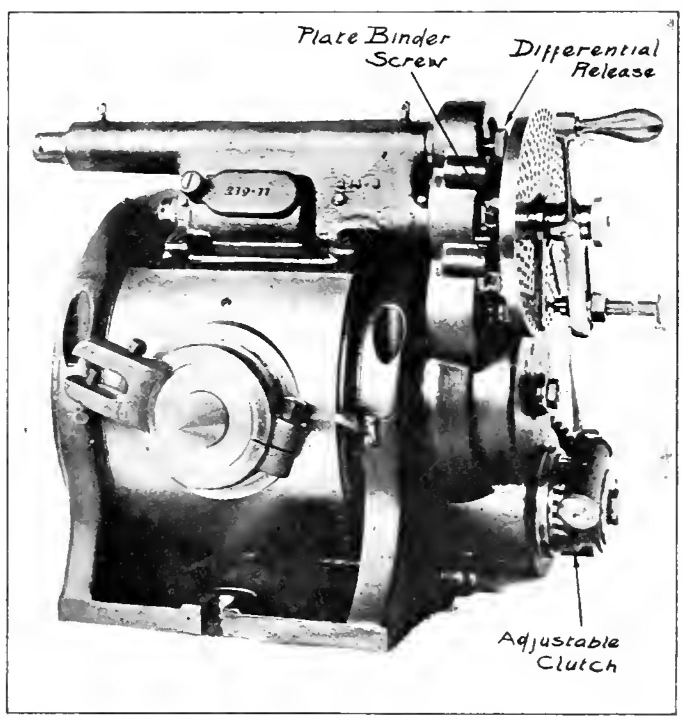
it be accomplished by rotating the crank, the pin would not come exactly over a hole. Should it be attempted to move both plate and crank in conjunction, it would be found that the back pin of the ordinary head would not engage with a back hole. In this head the back pin is done away with and the plate is held in position when resorting to plain indexing by a friction hold on the hub of the plate gear which is clamped or released by a suitable bolt conveniently located. By this means, work may be set regardless of the position of the plate and the plate can then be securely held in the position it takes when the work is so set. Those who have used the ordinary head will realize the advantage to be gained in doing away with the back pin and substituting the more flexible holding device.

In work requiring the head to be connected up for spiral cutting the roll over of the work is made more convenient by the presence of the adjustable clutch which, as explained above, allows the disconnection of the spiral cutting train so that the spindle and work may be revolved, or rolled over, without changing the position in relation to the cutter in a direction parallel with the feed motion.

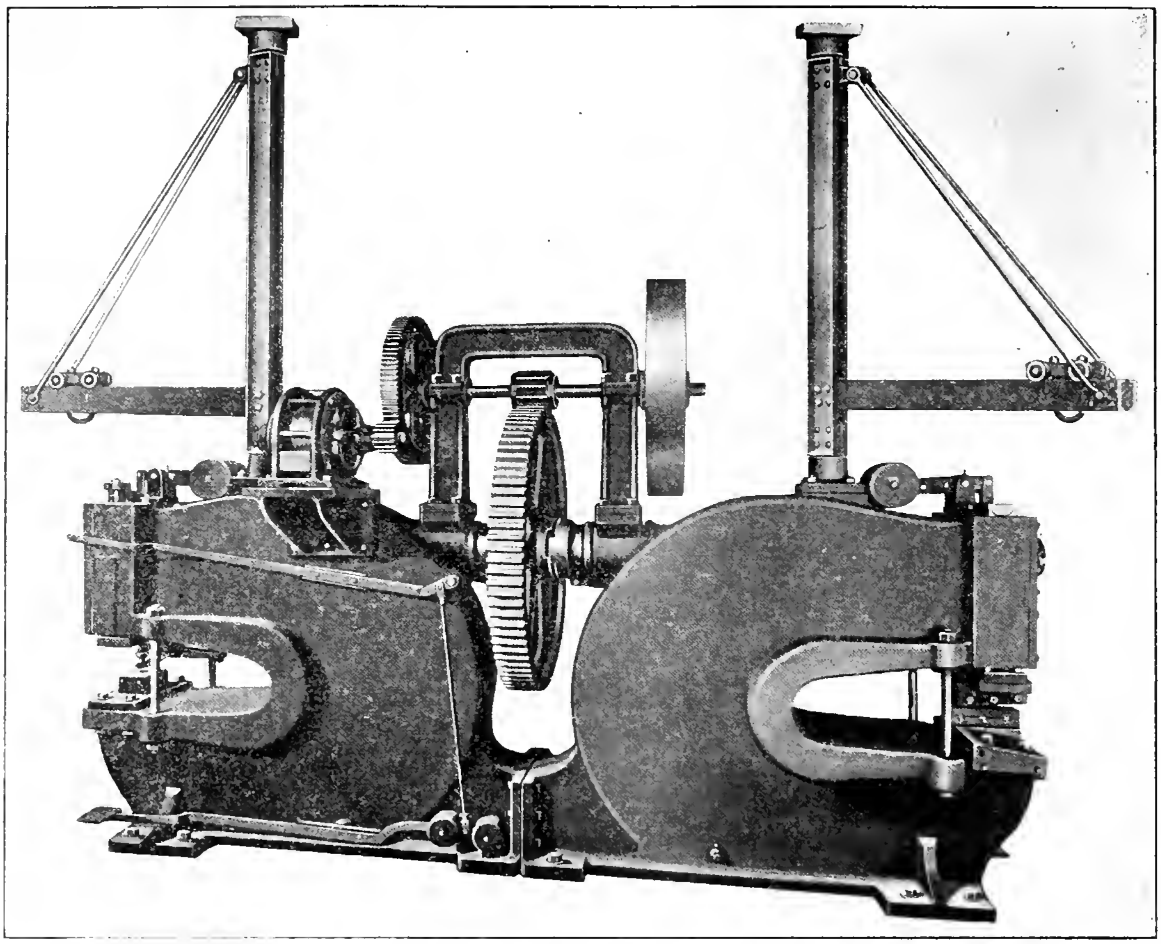
THE DRY KILN requires steam heat at all seasons of the year, and as planing mills are usually placed at quite a distance from other buildings (on account of the fire risk) it is inconvenient to carry the shavings any great distance, as for instance to a power-house, which should ordinarily be located in the power center of gravity of the locomotive department. Shavings are always very difficult to dispose of, and yet they have a certain amount of value as fuel if properly utilized. Considering these various points, it has seemed to the writer as if the best solution of the problem would be to put a small boiler plant, consisting possibly of only one boiler, in a wing alongside the planing mill, and feed this automatically with the shavings. The steam generated can be used to operate the dry kiln, and in winter time also to heat the planing mill. For this purpose the ordinary run of shavings would no doubt be ample, although they do not make a desirable fuel for the regular power-house, and the small amount of attention which such a boiler would need, as no moving machinery is involved, would, we think, be generally preferable and cheaper than attempting to carry the shavings to the power-house (if located as above described) and steam heat back again to the planing mill and the dry kiln. The shavings can be blown, in such a case, directly into the furnace by means of a fan driven by an electric motor, and the labor required for operating the boiler would be very small.—*Mr. G. R. Henderson at the New England Railroad Club.*

The Pennsylvania system uses between seven and eight million ties a year and during 1906 used nearly 160,000 tons of steel rails.





NEW UNIVERSAL INDEX AND SPIRAL HEAD FOR MILLING MACHINES.



HEAVY DOUBLE 36-INCH CINCINNATI PUNCH.

HEAVY DOUBLE 36-INCH PUNCH.

The Chicago & Western Indiana Railway Company has recently installed a heavy double 36-inch punch at its Chicago shops, which weighs complete about 45,000 lbs., and was furnished by the Cincinnati Punch & Shear Company of Cincinnati. It is driven by a direct connected, 10 h.p., General Electric motor, as shown, and is equipped with two cranes having 9 ft. arms. The frames are of the double wall box type, making them very rigid; the heads are extra long. The machine is equipped with the patent positive adjustable stop, described on page 65 of our February, 1905, issue, which allows the machine to be automatically stopped at any desired part of the stroke, making it valuable for such work as accurate center punching. The sliding clutch is also of the Cincinnati Punch & Shear Company's well-known patent type, the section of the driving shaft upon which the clutch slides being square, thus doing away with the use of feathers and keys.

Automobile Horse-Power Formula.—The Association of Licensed Automobile Manufacturers has adopted the following formula for rating the horse-power of automobile engines:

$$H.\ P = \frac{D^2 \times N}{2.5}$$

The *Horseless Age* recently published the following table based on this formula:

Bore of Cylinder, Inches.	Number of Cylinders. 1.	2.	3.	4.	6.
	Horse-power.				
3	3.6	7.2	10.8	14.4	21.6
3.25	4.2	8.4	12.7	16.9	25.3
3.50	4.9	9.8	14.7	19.6	29.4
3.75	5.6	11.2	16.9	22.5	33.7
4.	6.4	12.8	19.2	25.6	38.4
4.25	7.2	14.4	21.7	28.9	43.3
4.50	8.1	16.2	24.3	32.4	48.6
4.75	9.0	18.0	27.1	36.1	54.1
5.	10.0	20.0	30.0	40.0	60.0
5.25	11.0	22.0	33.1	44.1	66.1
5.50	12.1	24.2	36.3	48.4	72.6
5.75	13.2	26.4	39.7	52.9	79.3
6	14.4	28.8	43.2	57.6	86.4

Freight Car Efficiency.—When an intelligent citizen learns for the first time that the freight cars of the country make only 24 or 25 miles a day (The best figure that I know of for 1905 is 24.8. For the first six months of 1906 this rate was raised to 25.7.), he feels at once that something must be wrong and very wrong, but this is not necessarily the case. It is perhaps a pity that we have adopted a unit like this. Probably it would have been better to have said that our freight cars made 9,000 miles a year, or 9,500 miles a year. All of you would think it absurd that so and so's automobile only made 20 or 30 miles a day, when you knew it could make more than that in one hour; but when a man tells you he has run his automobile 9,000 miles in a year, he speaks as if he had made a pretty good record. Of course, no one expects an automobile to be running all the time. If it takes a run in the daytime, it probably does not take one at night. It has to be cleaned and it has to be repaired. Its owner needs rest and, sometimes, refreshment. Now, in just the same way there are a great many things which influence the rate of movement of a car. It has to be inspected, lubricated, repaired, loaded and unloaded. If it runs at night, it generally stands still all day and sometimes several days, and vice versa.

Now, a mile a day increase does not seem much to make, but its result is very material. An increase of one mile a day means an increase of 80,000 or 100,000 cars in this country, and that number of new cars would cost the railroads nearly $100,000,000; or, putting it in another way, an increase of one mile per day means an increase of 4 or 5 per cent. in the cars available for loading every day. My estimate is that the country loads about 150,000 cars a day, and this meagre increase of one mile means, therefore, an increase in the country of 6,000 or 7,000 carloads a day.—*Mr. Arthur Hale, General Supt. of Transportation, B. & O. R. R., before the Transportation Association of Milwaukee.*

At the close of the current year the Union and Southern Pacific Railways will have 4,700 miles of track protected by automatic block signals.

PERSONALS

Mr. C. B. Gray has been appointed assistant master mechanic of the Pennsylvania Railroad at Ormsby, Pa.

Mr. W. K. Christie has been appointed master mechanic of the Kalamazoo, Lake Shore & Chicago, with office at South Haven, Mich.

Mr. B. F. Elliott has been appointed assistant master car builder of the Mexican Central with headquarters at Aguascalientes, Mex.

Mr. M. M. Meyers has been appointed master mechanic of the Missouri Pacific, with headquarters at De Soto, Mo., succeeding Mr. A. S. Grant.

Mr. Leonard Ruhle has been appointed master mechanic of the Colorado & Northwestern, with office at Boulder, Colo., succeeding Mr. M. Fitzgerald.

Mr. R. P. C. Sanderson has resigned as superintendent of motive power of the Seaboard Air Line, to accept a similar position with the Virginian Railway.

Mr. F. C. Hudson has been appointed master mechanic of the Canadian Northern Quebec Railway Company, with headquarters at Shawinigan Junction, Que.

Mr. S. P. Spangler has been appointed master mechanic of the St. Louis, Watkins & Gulf, with office at Lake Charles, La., succeeding Mr. J. C. Ramsey, resigned.

Mr. H. W. Ridgway, master mechanic of the Colorado & Southern at Trinidad, Colo., has been transferred to Denver, Colo., in place of Mr. D. Patterson, resigned.

Mr. G. A. Baker has been appointed superintendent of motive power of the Santa Fe Central, with office at Estancia, N. M., succeeding Mr. T. J. Tonge, resigned.

Mr. W. L. Larry has resigned as division master mechanic of the New York, New Haven & Hartford to become an inspector for the Massachusetts railroad commission.

Mr. T. J. Tonge has resigned as superintendent of motive power of the Santa Fe Central to become connected with the El Paso & Southwestern at Santa Rosa, N. M.

Mr. P. Conniff, heretofore general foreman of the Baltimore & Ohio at Holloway, O., has been appointed master mechanic at Benwood, W. Va., succeeding Mr. F. C. Scott, resigned.

Mr. E. D. Andrews has been appointed master mechanic of the Sterling division of the Chicago, Burlington & Quincy, with headquarters at Sterling, Colo., vice Mr. F. Newton, resigned.

Mr. J. Dietrich has been appointed master mechanic of the Lincoln division of the Chicago, Burlington & Quincy, with headquarters at Lincoln, Neb., succeeding Mr. J. J. Buttery, who has been assigned to other duties.

Mr. M. A. Kinney, roundhouse foreman of the Baltimore & Ohio at Newark, O., has been appointed master mechanic of the Hocking Valley, with headquarters at Columbus, O., succeeding Mr. E. J. Powell, resigned.

Mr. M. J. La Court, foreman of the car department of the Chicago, Milwaukee & St .Paul at La Crosse, Wis., has been appointed general traveling inspector of cars for the entire Chicogo, Milwaukee & St. Paul system.

Mr. F. E. Doxey, heretofore foreman of shops of the Illinois Central at Waterloo, Ia., has been appointed master mechanic of the Des Moines, Iowa Falls & Northern, with headquarters at Iowa Falls, Ia., to succeed Mr. L. C. Rost, resigned.

Mr. A. S. Barrows, chief clerk to the second vice-president and general manager of the Buffalo & Susquehanna, has been appointed chief clerk to the general superintendent of motive power of the Rock Island Lines at Chicago.

Mr. George W. Wildin, assistant superintendent of motive power of the Lehigh Valley, has been appointed mechanical superintendent of the New York, New Haven & Hartford, with office at New Haven, Conn., to succeed Mr. F. T. Hyndman, resigned.

Prof. Charles Henry Benjamin.—The appointment is announced of Professor Charles Henry Benjamin to be dean of the Schools of Engineering of Purdue University, to succeed Dean W. F. M. Goss, who resigns in order to accept a similar appointment at the University of Illinois. Professor Benjamin comes to Purdue from the chair of mechanical engineering at Case School of Applied Science, which he has occupied with distinction since 1889, prior to which time he was, for three years, engaged in engineering practice and, for six years, as instructor and professor of mechanical engineering in the University of Maine, of which institution he is a graduate. He brings an unusually successful experience and valuable equipment as teacher, investigator, author, and engineer, and will be recognized as a worthy occupant of the chair so long and eminently filled by Dr. Goss.

BOOKS

The Art of Cutting Metals, by Frederick W. Taylor, M.E., Sc.D. Presidential Address presented at the last annual meeting of The American Society of Mechanical Engineers. Cloth. Price, $3.00.

This or any other publication of the Society may be had by addressing the Secretary, 29 West 39th Street, New York. It is not necessary to send orders through members. None of the publications of The American Society of Mechanical Engineers are copyrighted.

Effect of Scale on the Transmission of Heat Through Locomotive Boiler Tubes. By Edward C. Schmidt and John Snodgrass. Bulletin No. 11, University of Illinois Engineering Experiment Station. Published by the University at Urbana, Ill.

This bulletin records the results of several series of tests, both on actual locomotives and on specially designed apparatus, to obtain information concerning the effect of scale on the transmission of heat through the tubes. Part of this information was recently included in a paper before the Western Railway Club by one of the authors. The bulletin includes reports of a number of earlier tests in addition to those given in that paper.

Universal Directory of Railway Officials. 1907. Compiled under the direction of Mr. S. Richardson Blundstone, Editor of *The Railway Engineer*. Published by The Directory Publishing Company, Limited, 3 Ludgate Circus Buildings, E. C., London. United States Representative, A. Fenton Walker, 143 Liberty street, New York City. Price, 10 shillings.

Presents information as to the length of road in operation, gauge, number of locomotives and passenger and freight cars, and a directory of the officials of all the railroads in the world. Practically all tramways worked by power in the United Kingdom are included. The book is splendidly indexed; there is an index to countries, one to the names of the railways and one to names of the officials. It is clearly printed and well bound.

Production of Automobiles.—According to a consular report, issued by the Washington Bureau for Manufactures, the United States in 1902 produced only 314 machines as compared with 24,000 which were built in France. The production of the various countries in 1906 was as follows: Germany, 22,000; United States, 58,000; France, 55,000; England, 27,000; Italy, 18,000; Belgium, 12,000.

CATALOGS.

FLANGE UNIONS.—The Western Tube Company, Kewanee, Ill., is issuing a leaflet illustrating and describing the Kewanee union flange, which is made of malleable iron, with the exception of the brass seat.

SOMETHING COOLING FOR A HOT DAY. This is the title of an attractive 16-page folder, Bulletin 90, recently issued by the B. F. Sturtevant Company. It describes various types of electric propeller fans and illustrates their application.

RACK-RAIL LOCOMOTIVES.—A. Borsig, Tegel, Germany, is issuing a pamphlet (No. 1157) illustrating some of the rack-rail locomotives recently completed at his works both for German and other railways. Many locomotives from these works are in use in the mountains of South America. The catalog briefly considers the type in general and discusses the capacities and limitations of a number of locomotives recently built.

STORAGE BATTERIES FOR STATIONARY SERVICE.—The Westinghouse Machine Company is issuing an attractive catalog on this subject, which includes many illustrations and comprehensive descriptive matter of the latest designs of storage batteries. Details are included giving data and prices of the different sizes. Interesting curves are reproduced, showing the variations in capacity of storage batteries with the percentage rate of discharge, also with the rate of discharge in hours.

AIR COMPRESSORS AND PNEUMATIC TOOLS.—The Chicago Pneumatic Tool Company, Fisher Building, Chicago, is sending out two new catalogs. The first one, No. 23, contains over 100 pages and is devoted entirely to its Franklin air compressors. The second one, No. 24, is about the same size and covers the pneumatic tools and appliances, including Boyer and Keller hammers, Little Giant drills, sand rammers and hoists. Both of these publications are well indexed and strongly bound.

ROTARY SNOW PLOW.—A pamphlet recently issued by the American Locomotive Company illustrates and describes the rotary snow plow built by that company. The first part of the pamphlet contains a brief account of the work done by the rotary in fighting the snow, with illustrations of it in operation. Then follows a description of the plow, considering the particular features of the design. The last part of the pamphlet contains a set of rules for the guidance of those operating this type of plow.

SIX-WHEEL SWITCHING LOCOMOTIVES.—The American Locomotive Company has just issued the ninth of its series of pamphlets covering the standard types of locomotives. As the title indicates, this number of the series is devoted to six-wheel switching locomotives and contains half-tone illustrations and the principal dimensions of twenty-six different designs of this type. The designs illustrated range in weights from 102,000 to 176,500 pounds, and are adapted to a variety of service conditions.

THOMSON POLYPHASE INDUCTION WATTMETERS. Bulletin No. 4527 issued by the General Electric Company, Schenectady, N. Y., describes the latest form of these meters, which are made for the specific purpose of measuring energy in any two-phase, three-phase or monocyclic circuit. They are made in three types; one for house service with metal cover, and two for switchboard use, one having a metal cover and the other a glass cover. The bulletin gives catalog numbers and capacities, etc., of the various sizes, and a large number of connection diagrams showing the method of installation on different classes of circuits.

FORCING PRESSES.—The Watson-Stillman Company of New York City is sending out catalog No. 70, which contains about 130 pages and is devoted entirely to forcing presses, or those tools and presses whose main purpose is the making or breaking of forced fits or for driving broaching tools and similar work. A large part of the catalog concerns new machines which have not been described in previous catalogs. Many of the tools are specially adapted for railroad shop conditions. In addition to the manufacture of its standard tools, this cimpany is in position to undertake the building of special machines to meet the needs of the purchaser.

VALVES AND STEAM AND WATER SPECIALTIES.—A 60-page catalog, known as No. 9, has just been received from the Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburg, Pa. The construction of the various devices manufactured by them is described and clearly illustrated. Among these various specialties are the Anderson cushioned non-return valves, Anderson reducing valves, "Clean Seat" valves, Anderson cushioned check and hand stop valve, Golden high and low pressure tilting steam trap, Anderson balanced plug cock, Anderson balanced plug locomotive blow-off, Anderson automatic and counter-balanced valve for standpipe and tank service, Anderson automatic standpipes, Anderson automatic track float valves, Anderson altitude valves and Anderson ideal strainer and fish traps.

BRASS AND IRON STEAM ENGINEERING SPECIALTIES.—A very complete 281-page catalog (No. 9) has just been prepared for distribution by The Wm. Powell Company, 2525 Spring Grove avenue, Cincinnati, Ohio. The construction and merits of each article are described in detail. The book is provided with a carefully prepared index and is divided into the following general divisions: "White Star" valves, "Model Star" valves, "Union" composite disc valves, hydraulic valves, iron body valves and flanges, throttle and gate valves, blow-off valves and swing check valves, injectors, standard miscellaneous valves, lubricators, gas engine trimmings, oilers and grease cups, staple boiler and engine trimmings, and revolving chucks. An appendix of 18 pages contains a series of tables and rules giving, in a concise form, information required by engineers and shop managers.

GRINDING WHEELS AND MACHINERY.—The Norton Company, Worcester, Mass., is issuing a new edition of its catalog which supersedes all previous issues. This has 146 pages, is printed on heavy paper and includes a large number of excellent illustrations of grinding machines and grinding wheels of all shapes and sizes. These wheels are made of alundum, which is said to be the hardest, sharpest and most durable abrasive material known. The catalog briefly describes the method of manufacture of the wheels, gives rules for calculating proper speeds or diameters, as well as tables of rim speeds for different revolutions per minute, etc. Dimensioned line drawings are given of a large variety of special wheels suitable for different makes of grinding machinery and for the different classes of special work. A section of the catalog is devoted to a discussion of oil stones manufactured by this company. The latter half of the book includes illustrations and descriptions of a large variety of grinding machines.

BALANCED COMPOUND LOCOMOTIVE.—The Baldwin Locomotive Works is issuing Record No. 62 on the subject of balanced compound locomotives. It contains a large number of half-tone illustrations and line drawings of this type of locomotive, as well as a discussion of the merits of the type and a description of some of the recent designs. Some very interesting data concerning the remarkable mileage records made by the balanced compound locomotives on the Atchison, Topeka & Santa Fe Railway are included. Among these might be mentioned engine 509, which was received on May 17, 1904, and made a mileage of 144,927 miles up to October 15, 1906, when it was sent to the shops for tire turning. During this period of 2½ years the engine was out of service only eleven days. The pamphlet also includes a number of suggestions for running balanced compound locomotives. The latter half gives illustrations and dimensions of fourteen designs of balanced compound locomotives built by this company.

NOTES

WILMARTH & MORMAN COMPANY.—This company, of Grand Rapids, Mich., advises that its shipments for the first seven months of the year exceed those for a corresponding period of last year by 26 per cent.

AJAX METAL CO.—A decision of the Circuit Court of the U. S. District of N. J., was rendered on July 31 in favor of the Ajax Metal Company relative to infringements made upon their patents covering Plastic Bronze. This decision fully sustains all of the claims made by the company.

PITTSBURG FILTER MFG. CO.—Mr. L. W. Jones has resigned as president and also from the board of directors of this company and will open an office in Pittsburg as consulting engineer along the lines of municipal and industrial filtration plants, water softening and sewerage disposal plants.

BLISS ELECTRIC CAR LIGHTING COMPANY.—Mr. John Reid, who for several years has been connected with the Consolidated Railway Electric Lighting & Equipment Company, has accepted the position of assistant to the vice-president in charge of sales of the Bliss Electric Car Lighting Company, with headquarters at its New York office, Night & Day Bank Building.

AMERICAN LOCOMOTIVE COMPANY.—This company has recently received an order of 101 four-wheel motor trucks for the Brooklyn Rapid Transit Company. These will be built to designs prepared by the builder and will follow closely M. C. B. standards, embodying as far as possible the practices of locomotive construction, thereby insuring strength combined with easy riding qualities.

BLISS ELECTRIC CAR LIGHTING CO.—This company has received an order from the Baltimore & Ohio Railroad for equipping the Royal Blue limited trains with its system of electric lights and fans. The Pullman Company has also ordered Bliss Axle light equipment to be applied to all Pullman private cars. It is stated that the company has thus far this year furnished more than 75 per cent of the axle light equipments purchased by railway companies.

AMERICAN STEAM GAUGE & VALVE MFG. CO. The Boston *Journal* recently published a reproduction of an advertisement of this company which appeared over 50 years ago. The company were organized in 1854, having purchased the rights to manufacture the Bourdon gauge, and started with a force of three men and seven boys. To-day is has nearly 500 skilled workmen engaged in the manufacture of its well-known gauges, valves and steam engine indicators.

CINCINNATI PLANER CO. This company announces that it has increased its capital from $200,000 to $400,000. The additional capital will be used for the construction of a new plant now being built at Oakley, Ohio, near Cincinnati, which will be completely equipped with new machinery and will be used for building the larger size planers. The present plant will be used for the smaller size machines. It is expected that the new plant will be in operation before the first of October.

WESTINGHOUSE ELECTRIC COMPANY.—Among the large orders received in July by the railway department of this company were two of more than ordinary importance. One of these was from the Brooklyn Rapid Transit Company for 400 electric railway motors, 200 of which are of 200 h.p. capacity for elevated cars and the balance of 60 h.p. capacity for surface cars. The same company will also furnish the multiple unit control system for the elevated equipment. Another large order was from the Schoepf interests of Cincinnati, and included a complete equipment of electrical apparatus for twenty-four sub-stations as well as four Westinghouse turbo-generators aggregating 26,000 h.p.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

OCTOBER, 1907

A RATIONAL APPRENTICE SYSTEM.

New York Central Lines.

Synopsis.

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PART IV.

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Part III.

The Apprentice Courses or Schedules.

Schedules, or courses, have been arranged for the different trades which are followed as closely as possible. As may be seen, these schedules are sufficiently flexible to meet the needs of the various grades and types of boys who may be enrolled. The shop instructor is responsible for seeing that they are "lived up to" and he must give reasons for any deviations from them. He usually has a schedule for the changes in his shops arranged for a considerable period in advance. He keeps in close touch with the various foremen and carefully studies the situation in the shop, so as not to cripple any one branch or department by making too many changes at one time, or by reducing the quota of boys in a department without taking the proper steps to keep up the work. When changes are necessary he submits his recommendations to the shop superintendent, who approves them and issues the necessary orders to make them effective.

Machinist, boiler maker, tin and copper smith and painter apprentices are to be assigned to the roundhouse for short periods during their apprenticeship Those who show a liking for drawing are assigned to the drawing room to assist the shop draftsman for periods of from 60 to 90 days. At the Brightwood shops of the Big Four the general foreman, Mr. Bauer, is making a practice of taking some of the apprentices into his office for a short time, to enable them to become familiar with the methods of keeping records and office work in general.

The arrangement of the courses for the various trades is as follows:

MACHINIST—(Four Year Course).

Helping in Shop	0 to 3 months
Bench Work	6 " 12 "
Light Tool Work	3 " 6 "
Heavy Tool Work	3 " 12 "
In one of either the Air Brake Department, Tool Room or Brass Room	3 " 6 "
Erecting Shop	18 " 24 "

This schedule allows fifteen months above the minimum in the various departments, which can be divided between those in which the apprentice shows the most adaptability.

BOILER MAKER—(Four Year Course).

Heating Rivets, etc	3 to 6 months.
Light Sheet Iron Work	12 " 15 "
Flue Work	3 " 6 "
Riveting, Chipping, Caulking and Staybolt Work	12 " 18 "
Flanging and Laying Out	0 " 3 "
General Work	6 " 12 "

This allows twelve months above the minimum in the various departments, which can be divided between those in which the apprentice shows the most adaptability.

BLACKSMITH (Four Year Course).

Hammer Work and Helping	3 to 12 months.
Light Fire	12 " 24 "
General Work	12 " 24 "
Heavy Fire	3 " 12 "

This leaves eighteen months above the minimum in the various departments which can be divided between those in which the apprentice shows the most adaptability.

MOLDER (Four Year Course).

Helping	3 to 6 months.
Core Work	6 " 12 "
Light Work	6 " 12 "
General Molding	18 " 24 "
Dry Sand	1 " 12 "

This leaves fifteen months above the minimum in the various departments, which can be divided between those in which apprentice shows the most adaptability.

PATTERN MAKER (Three Year Course).

Helping in Pattern Shop	0 to 3 months.
Foundry	3 " 6 "
Machine Work	3 " 12 "
Bench Work	24 " 30 "

This allows six months above the minimum in the various departments, which can be divided between those in which apprentice shows most adaptability.

TIN AND COPPER SHOP—(Three Year Course).

Helping Around Shop	0 to 3 months.
Pipe Work	6 " 12 "
Sheet Iron Work, Including Jackets	6 " 12 "
Tinware	6 " 12 "
Copper Smithing	6 " 12 "

This allows twelve months above the minimum in the various departments, which can be divided between those in which the apprentice shows most adaptability.

PAINTER—(Three Year Course).

Helping	6 months.
Burning Off, Sand Papering and Truck Work	6 "
Rough Stuff and Coating	6 "
Staining, Graining and Varnishing	6 "
Striping, Lettering and Designing	12 "

PLANING MILL—(Three Year Course).		
Helping	1 to	4 months.
Running Simple Machines, Including Sharpening and Setting Tools	12 "	20 "
Running More Complex Machines, Including Sharpening and Setting Tools	12 "	20 "
Laying Out Work and Templates, Working from Blue Prints	16 "	28 "

CAR BUILDER (Four Year Course).		
Helping Around Shop	0 to	3 months.
Trucks	6 "	12 "
Platform	6 "	12 "
General Body Work	18 "	24 "

Drawing Courses.

Mechanical drawing, of course, forms the backbone of the educational work. The method of teaching this differs radically from the methods ordinarily used, whether in special drawing schools and classes or in technical schools. As stated on page 205 of the June, 1907, issue, no preliminary geometrical exercises are introduced, but models or actual parts are used from the very first and every step taken is along practical and common sense lines.

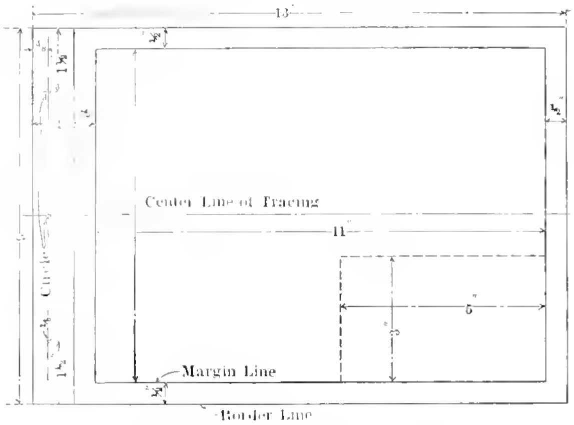


FIG. 1.—BORDER LINES ON TRACINGS.

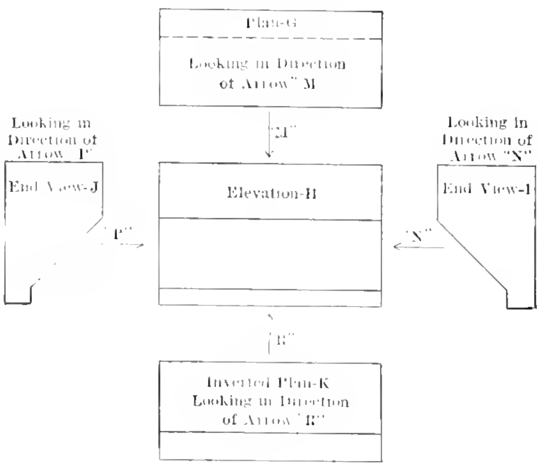


FIG. 2.—ARRANGEMENT OF VIEWS.

General Instructions.

When the apprentice reports to the drawing school for the first time he is given a drawing board, which is numbered and must be placed in a corresponding space in the case when not in use. He is told to place his name on his T-square and other supplies, is briefly instructed as to the use of the drawing board, T-square and scale and is told how to sharpen his pencil and impressed with the necessity of keeping it sharp. These instructions are made as simple and brief as possible, after which he is given a blue print sheet, about 5½ x 9 in. in size, showing how his paper is to be placed on the drawing board and laid out, how the views of the object are to be arranged on the sheet and the arrangement of the title in the lower right hand corner. At the lower part of this sheet, which is reproduced in Fig. 3, the correct style* of making arrow heads and numerals is shown in contrast with an incorrect style.

* The reproduction does not do this justice.

He is then handed an instruction sheet and model for the first exercise and is told to go ahead. Usually the first drawing is completed two hours after the boy first reports. The instruction sheets are blue prints, 5½ x 9 in. in size, and contain directions as to just what is to be done, thus relieving the instructor to a considerable extent and enabling him to give his attention to each boy as he may require assistance. The instructor must O. K. each drawing before it is removed from the board, and as soon as one is completed he gives the apprentice the instruction sheet and model for the following one. The first exercises are very simple, but they gradually grow more and more difficult, geometrical principles being introduced as they are found necessary. Accuracy is insisted on from the start. Lettering is taught incidentally in connection with the title on the sheet.

In each school room a large blue print sheet is posted, containing the following instructions:

GENERAL.

The longer dimension of a tracing (as a rule) shall be the horizontal one.

A separate drawing shall be made for each detail.

Each tracing shall be bounded by border lines; margin lines shall be drawn ½ in. inside the border lines and parallel to them.

Each tracing shall have a second border line along the left hand end 1 in. outside of the first. Three ⅛ in. circles shall be placed as shown in Fig. 1.

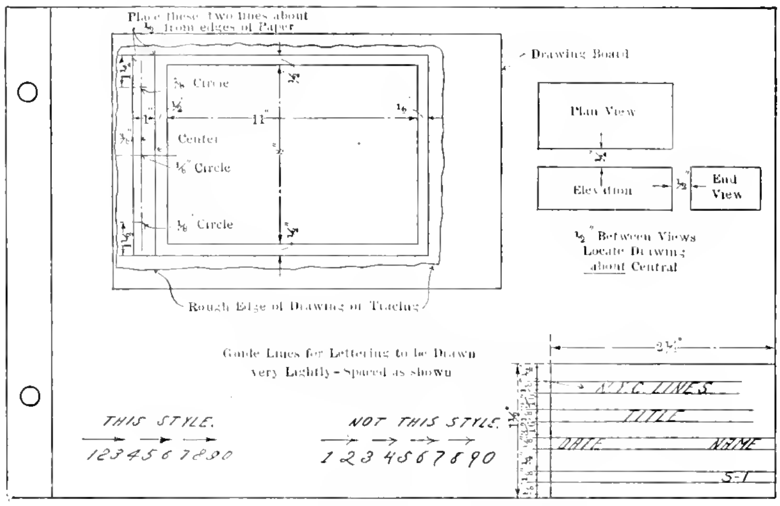


FIG. 3.—GENERAL INSTRUCTION SHEET.

SIZE.

All tracings shall be made on the following sizes (measured over all), each of which shall be known by an initial.

Z — 73 x 36 in.	R — 49 x 18 in.	V — 25 x 18 in.
Q — 73 x 24 in.	P — 49 x 9 in.	T — 19 x 12 in.
Y — 49 x 36 in.	X — 37 x 24 in.	S — 13 x 9 in.

Tracings shall be trimmed 1/32 in. outside of the border lines.

LINES.

Lines shall have the following widths:

Shade and margin lines 3/128 in.
Ordinary and border lines 1/64 in.
Hidden lines (dashes 3/16 in. long, spaces 1/32 in. long) 1/64 in.
Cross section lines 1/64 in.
Dimension lines 1/128 in.
Center lines 1/128 in.

LETTERING.

Letters and figures shall be of the style and size used on this tracing. (See Fig. 3).

VIEWS.

The relative position of the views is to be as shown in Fig. 2. (The views G, H, and I will usually be sufficient).

At least ½ in. should be left between views.

TITLE.

A blank space 3 x 5 in. in the lower right hand corner of the tracing should be reserved for a title.

Wherever possible use the title shown in Fig. 3.

REVISION.

When a drawing has been accepted by an instructor and is returned later for further work it should be reissued by adding "A," "B," "C," etc., after the drawing number in the title. Thus—No. 26-A.

DIMENSIONS.

Dimensions of 24 in. or less shall be given in inches:

Dimensions between 24 and 25 in. are given thus: 2′ 0-½″. Dimensions over 24 in. are given in feet and inches. Exceptions to this rule (when inches only will be used) are as follows: Diameters of

wheels and boilers. Dimensions of sheets of metal and cloth. Sizes of window glass. Dimensions of cylinders and length of elliptic springs.

Indicate on all drawings whether holes are to be drilled, cored or punched. Thus—13/16" Drill, ⅝" Core, etc.

Master Mechanic's decimal gauge shall be used in specifying sizes of wire and sheet metal.

When the space for a dimension is ¼ in. or less it is to be placed thus: ⅛".

FINISH.

Surfaces to be finished shall be indicated by the word "finish" opposite them.

CROSS REFERENCES.

Cross references shall be made to various points which require particular attention, thus: ⅜" Drill. See note No. 1.

SECTIONS.

Sections are to be drawn as shown in diagram No. 4.* A section is to be noted where taken by the first letters of the alphabet and the section itself should have below it: Section at A-B.

SHADING.

Shading is to be used as shown in Diagram No. 5*. See the instructor before using shade lines.

* Not reproduced.

The Locomotive Course in Detail.

A good idea of the arrangement of the courses and the principles governing them can probably be best conveyed by reproducing some of the more important instruction sheets, by presenting photographs of the models or objects and considering the course for the locomotive department in detail.

In the first exercise, Fig. 4 (a drilling block), the student has little more to do than to copy, except that the sketch on the

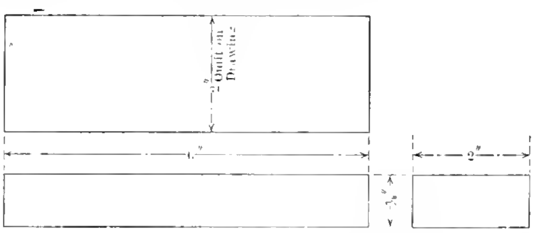


FIG. 4.—INSTRUCTION SHEET FOR FIRST DRAWING EXERCISE.

instruction sheet is not drawn to scale. All of the dimensions are supplied and the views are properly arranged. The dimension marked "omit on drawing" is placed on the instruction sheet to assist the student in locating the drawing centrally on the sheet.

The second exercise, Fig. 5 (a lap joint detail), is a little more complicated and the student is asked to supply the missing view. The use of the dotted or invisible line is also introduced. As an illustration of the care which it is necessary to use in preparing instruction sheets the following incident may be

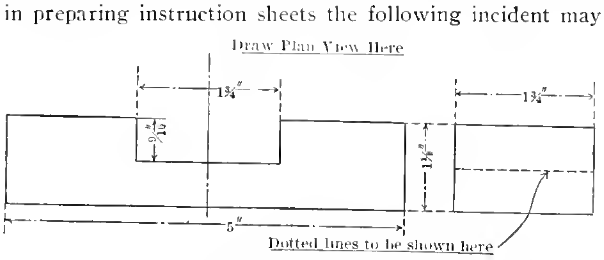


FIG. 5.—SECOND EXERCISE—A LAP JOINT DETAIL.

quoted. On the first sheets which were issued the notation calling for the addition of the missing view read "Plan Here." The boys had been carefully instructed to place the drawings centrally on the sheets, and as this required some calculation before beginning to lay out the drawing, they understood the notation to mean that any preliminary calculations concerning the placing of the views on the sheet were to be made on the spot indicated by the notation. It was necessary to revise it to read "Draw Plan View Here." In the earlier exercises in the course only those notations which are not underlined are to be copied on the drawing. After the apprentices become accustomed to the work it is, of course, not necessary to use such precautions.

In the third exercise, Fig. 6 (a lap joint detail), a missing view must be added which involves the use of the dotted line and certain dimensions are to be supplied, so that the piece will fit the part shown in the previous exercise.

The fourth and sixth exercises, which concern a milling jig and a drill clamp are a little more difficult than the first ones, but do not involve any new principles. The fifth exercise, Fig

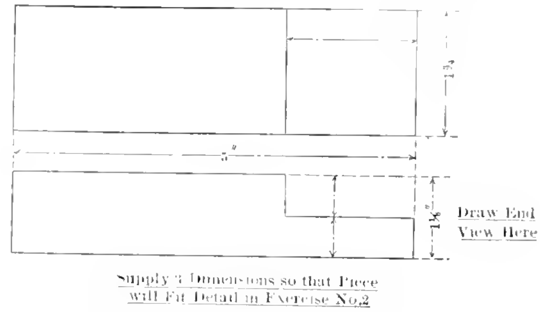


FIG. 6.—THIRD EXERCISE—A LAP JOINT DETAIL.

7 (an anchor plate), does not involve any new principle except that the dimensions are not placed on the drawing but in a table, and the student is expected to locate them properly on the drawing. It must, of course, be understood that none of

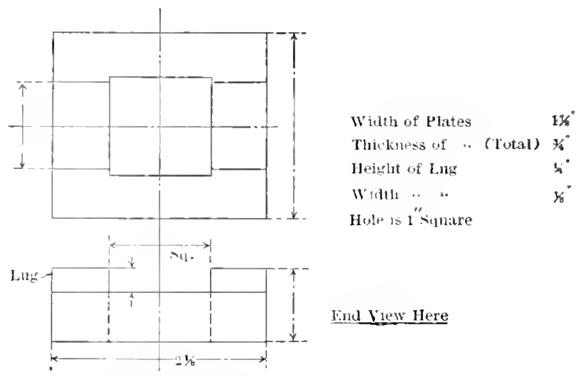


FIG. 7.—FIFTH EXERCISE—AN ANCHOR PLATE.

the sketches on the instruction sheets are drawn to scale so that it is impossible for the student to copy them.

The seventh exercise, Fig. 8 (a pipe center body), introduces for the first time the use of the triangle for the drawing

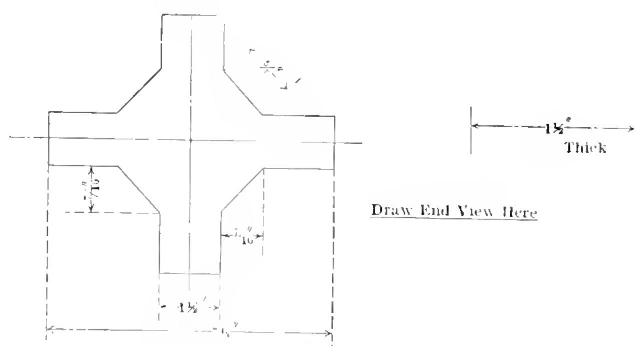


FIG. 8.—SEVENTH EXERCISE—A PIPE CENTER BODY.

of other than vertical lines, and the eighth exercise, Fig. 9 (a planer block), involves the use of the protractor. The next five exercises review the various principles which have thus far been introduced; exercise thirteen, Fig. 10 (a tool jig), being

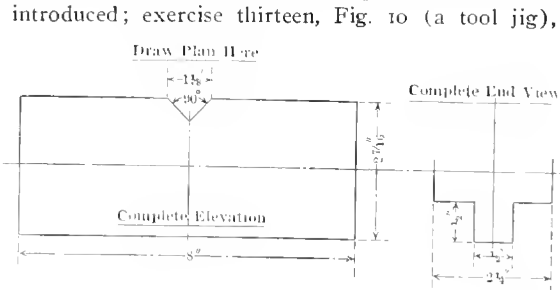


FIG. 9.—EIGHTH EXERCISE—A PLANER BLOCK.

compartively simple and yet requiring more or less thought on the part of the student in order to lay it out correctly.

Exercise fourteen, Fig. 11 (a hose gasket), is the first one

requiring the use of the compass; one missing dimension is to be supplied, but this is obtained by calculation and not from the actual part, although the apprentice has this before him while working.

In exercise fifteen, Fig. 12 (a vibrating cup), sectioning is

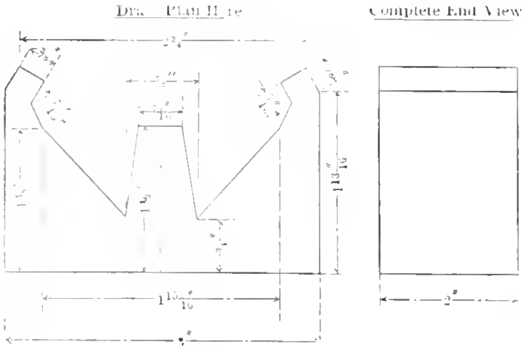


FIG. 10.—EXERCISE THIRTEEN—A TOOL JIG.

introduced for the first time. In the following exercise, Fig. 13 (a handle plate), the student is asked to draw a sectional view without assistance.

The criticism may be made that the exercises are too simple and that the progress is slow, but no one interested has as yet complained of this and experience has demonstrated that every step has been needed; in fact, when the course was revised and rearranged some time ago it was made even more simple than

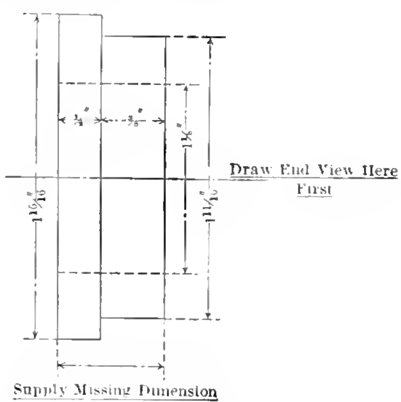


FIG. 11.—EXERCISE FOURTEEN—A HOSE GASKET.

when first introduced. It has been found advisable to cut the more complicated models into two or three sections, and Figs. 14, 15 and 16 are photographs of several of the models, beginning with exercise fourteen, showing how some of them have been cut into sections at the Brightwood school. These views also give some idea of the progress made during the earlier part of the course. The figures near the objects indicate the number of the exercise with which they are used. Although

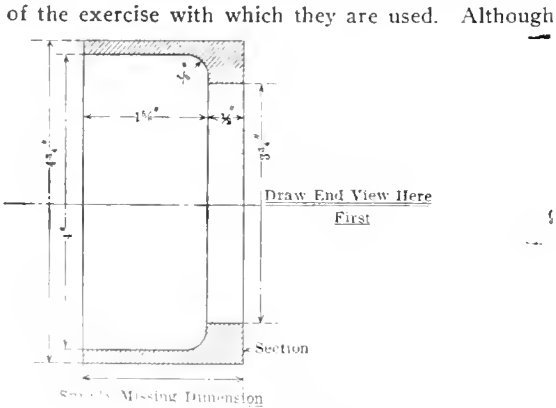


FIG. 12.—EXERCISE FIFTEEN—A VIBRATING CUP.

the aim has been to make each exercise a little more difficult than the preceding one, it has been found advisable in order to interest and encourage the students to occasionally introduce simpler exercises which review some of the more common principles and serve to give the boys some idea of the advancement which they have made.

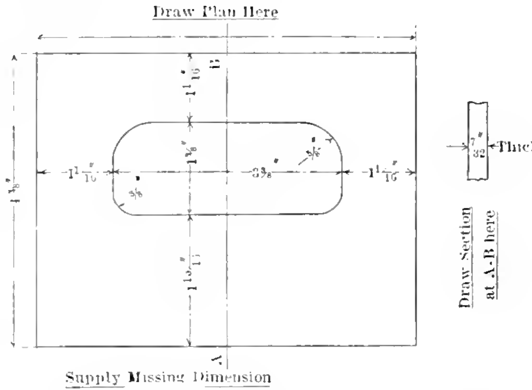


FIG. 13.—EXERCISE SIXTEEN—A HANDLE PLATE.

Exercises seventeen, eighteen, nineteen and twenty, a vestibule guard, bushing, door hasp and spanner nut, are introduced principally for giving practice in the use of the compass. In the first two of these exercises missing dimensions are to be supplied from the model. The last one, Fig. 17, is the first one requiring the division of the circumference of a circle.

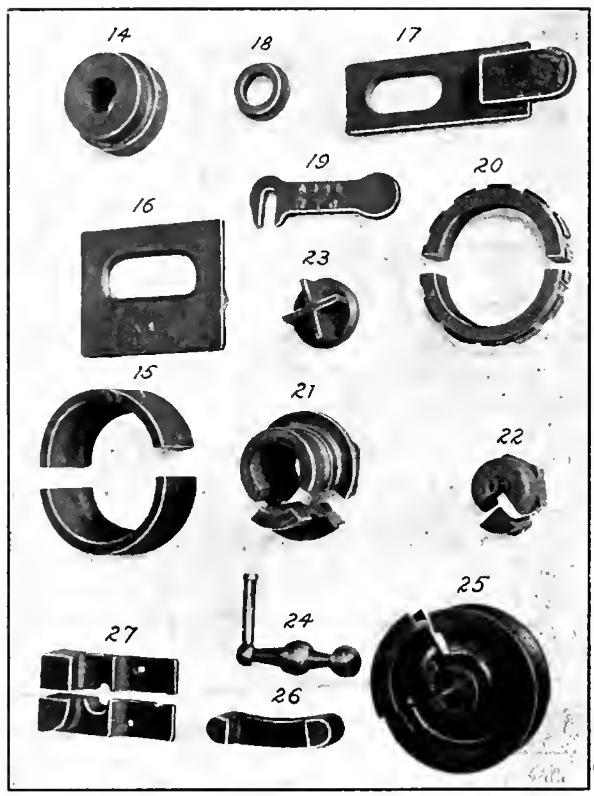


FIG. 14.—NUMBERS INDICATE THE DRAWING EXERCISE.

Exercise twenty-one, Fig. 18 (a brake nut), requires the drawing of a hexagon. The following five exercises, 22, 23, 24, 25 and 26, a check nut, an air valve for an air pump, an injector handle, a flanged pulley and a latch guide, are a little

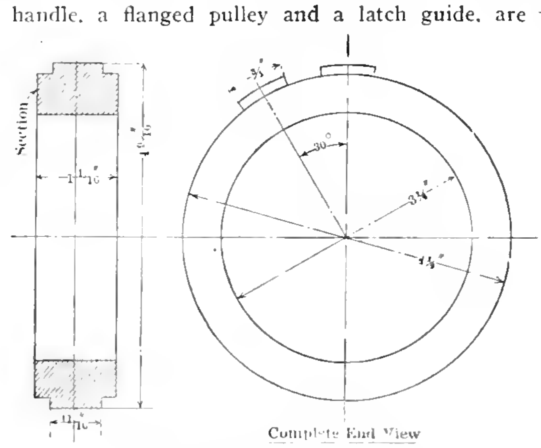


FIG. 17.—EXERCISE TWENTY—A SPANNER NUT.

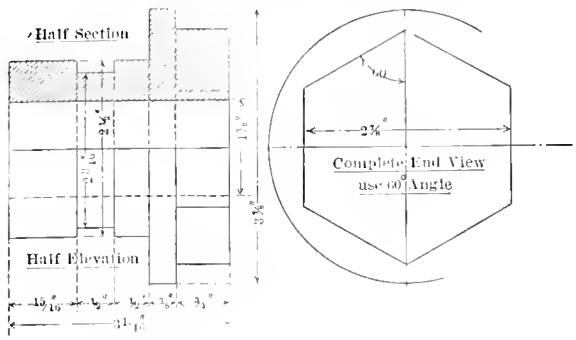


FIG. 18.—EXERCISE TWENTY-ONE—A BRAKE NUT.

more difficult, but do not involve any new principles. Exercise twenty-seven, Fig. 19 (hinge plate), is the first one requiring the laying out of bolt or screw holes. Exercises twenty-eight and twenty-nine, a tool post slide and a lathe saddle, are simple and are introduced mainly to bring into practice the use of the

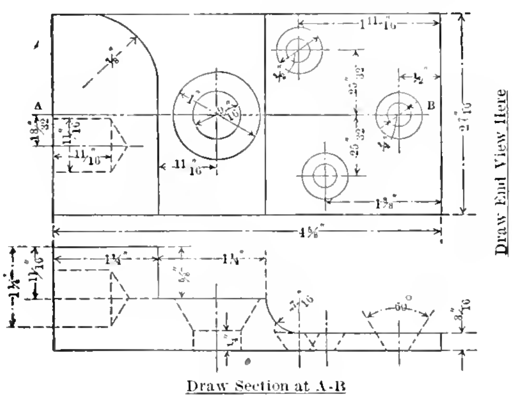
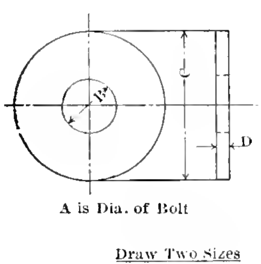


FIG. 19.—EXERCISE TWENTY-SEVEN—A HINGE PLATE.

protractor and triangles. Exercise thirty, as may be seen from the photo, is more difficult to draw and requires more or less ingenuity in laying out. Exercise thirty-one, Fig. 20, introduces the use of a table of dimensions showing different lines of standard washers. The student is required to draw two different sizes of washers from the dimensions in the table.



A	B	C	D
¼″	5/16″	⅝″	.065″
⅜″	7/16″	1″	.083″
½″	9/16″	1⅛″	.12″
⅝″	11/16″	1½″	.12″
¾″	13/16″	1¾″	.12″
⅞″	31/32″	2″	.134″
1	1⅛″	2½″	.165″

FIG. 20.—EXERCISE THIRTY-ONE—STANDARD WASHERS.

Up to this point most of the dimensions have been supplied on the instruction sheets and exercise thirty-two, Fig. 21 (a frame filling piece), is the first one requiring all the dimensions to be supplied from the model or actual part. One reason why such unsatisfactory progress is often made when students start

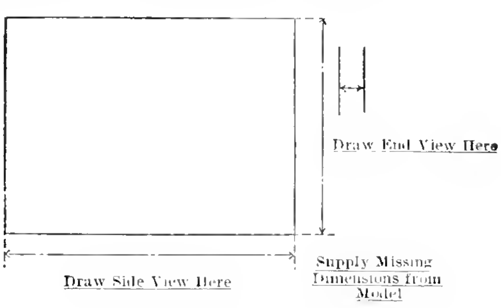


FIG. 21.—EXERCISE THIRTY-TWO—A FRAME FILLING PIECE.

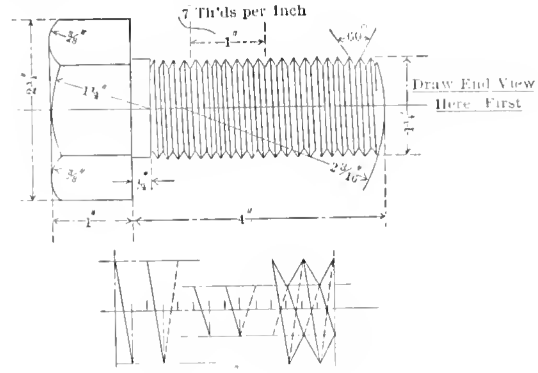


FIG. 22.—EXERCISE THIRTY-FIVE.

to draw the actual parts is that they have not had sufficient preliminary practice in dimensioning drawings. In this course, however, the dimensions are all given and located on the first sheets, then gradually the student is required to supply one, two, or three dimensions, and finally, after he has made thirty-one drawings, he is called upon to supply all the dimensions, but note that the drawing is a simple one and the location of the dimension lines is indicated. This is also true of the following exercise, No. 33. On this drawing a notation is required to the effect that the holes are to be drilled to the size shown. The following exercise, No. 34, an injector nozzle, is quite complicated, as may be seen from the photograph, but does not involve the use of any new principles.

Exercise thirty-five, Fig. 22, is a 1¼-in. bolt with a hexagon head. This involves the drawing of threads and the sketch on the lower part of the sheet is for the instruction of the student and is not to be reproduced on the finished drawing. The following six exercises, which cover an eccentric set screw, a ⅝-in. T head bolt, a regulator spring case, boiler plug, pump valve seat and a hose coupling, are introduced to give the student practice in the drawing of threads.

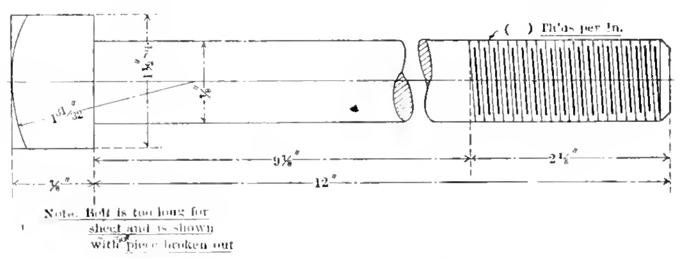


FIG. 23.—EXERCISE FORTY-TWO.

Exercise forty-two, a ⅞-in. bolt with a square head, Fig. 23, requires that the threads be indicated by the conventional method. It also calls attention to the principle of breaking a piece in order to get the drawing on the sheet.

Exercise forty-four, Fig. 24, introduces a table containing information as to boiler tubes and this instruction sheet is retained by the student to be used in connection with work in his problem course. The following eight exercises do not involve any important new principles and are introduced mainly to fa-

A	B	C	D	E	F
1½″	.393	1.767	.095″ .109″	.419 .480	13 12
1¾″	.458	2.405	.095″ .109″	.494 .566	13 12
2″	.524	3.142	.095″ .109″ .12″	.583 .654 .709	13 12 11
2¼″	.589	3.976	.095″ .109″ .12″	.643 .739 .803	13 12 11

A = Outside Diameter
B = Sq. Ft. Heating Surface per Ft. of Length
C = Area of Section in □″
D = Thickness of Tube in In.
E = Area of Metal in □″
G = Birmingham Wire Gauge

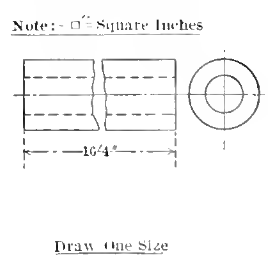


FIG. 24.—EXERCISE FORTY-FOUR—BOILER TUBE DATA.

miliarize the student with the use of tables giving dimensions and data for several different lines and to give him practice in laying out bolt holes.

Exercise forty-six, Fig. 25, is of special interest as it intro-

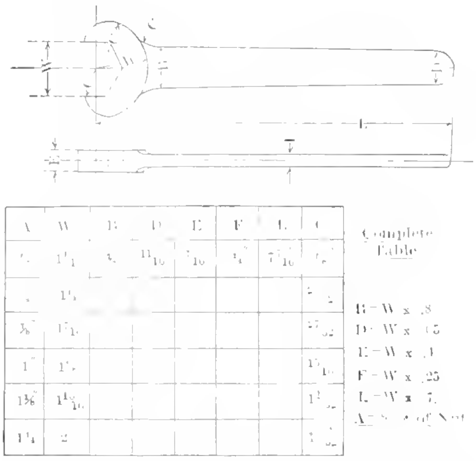


FIG. 25.—EXERCISE FORTY-SIX—WRENCH PROPORTIONS.

duces a formula which the student is to use in order to complete the table of wrench proportions.

Exercise forty-eight gives a table of dimensions for several different lines of 90 deg. cast iron elbows and requires the changing of the decimals in the table to fractions. To assist the student in doing this he is referred to the table of decimal equivalents in Colvin's "Machine Shop Arithmetic."

In several of the exercises thus far, the student has been asked to supply most or all of the dimensions, but the dimension lines were located. In exercise fifty-three, Fig. 26 (a coupler

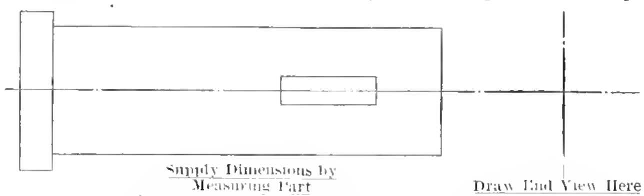


FIG. 26.—EXERCISE FIFTY-THREE—A COUPLER PIN.

pin), the student is for the first time asked to supply all of the missing dimensions with no direction as to how many are to be used, or where they are to be located. The two following exercises, a brake lever and a U-bolt, are similar to this.

Exercise fifty-six, a beveled washer, contains no instructions other than the location of the various views. This instruction sheet is reproduced in Fig. 27. The exercises following this and up to No. 70 review the principles which have been introduced to this point. Several of them contain no instructions other than notations as to the location of the different views, as in exercise fifty-six. The dimensions are in all cases to be supplied

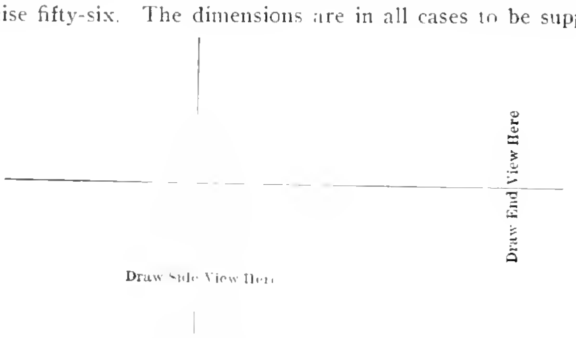


FIG. 27.—EXERCISE FIFTY-SIX—A BEVELED WASHER.

from the object itself, except in one instance, exercise sixty-six, which is rather complicated.

The first sixty-nine exercises are all drawn to full size. Beginning with exercise seventy, Fig. 28, larger objects are considered and they must, of course, be drawn to a smaller scale. These parts are supplied from the storehouse or shop as they are needed. The instruction sheet for exercise seventy is self-explanatory. Each apprentice is assigned a line number and in laying out the crank pin he must use the dimensions for that line. The table must also be copied on the drawing and the missing dimensions be supplied. The next seven exercises are quite similar to this and cover the rear and main crank pins for the Class G engines, which are to be drawn half size; the main crank pin to be drawn to a scale of 3 in. per foot; the quadrant for reverse levers, reverse lever and throttle lever, each drawn to a scale of 3 in. per foot and the M. C. B. standard axles to be drawn to a scale of 1½ in. to the foot.

Beginning with exercise seventy-eight, Fig. 29, the dimensions are taken from the actual parts, instead of from a table of dimensions as in the exercises immediately preceding. The instruction sheet for this exercise needs no explanation. It gives complete instructions to the student as to just what is required. Up to the seventy-eighth exercise the drawings are all such as could be placed on the smaller standard sheet (S). The objects considered have been simple so that only a short time was required to complete the drawing. This served to keep up the interest

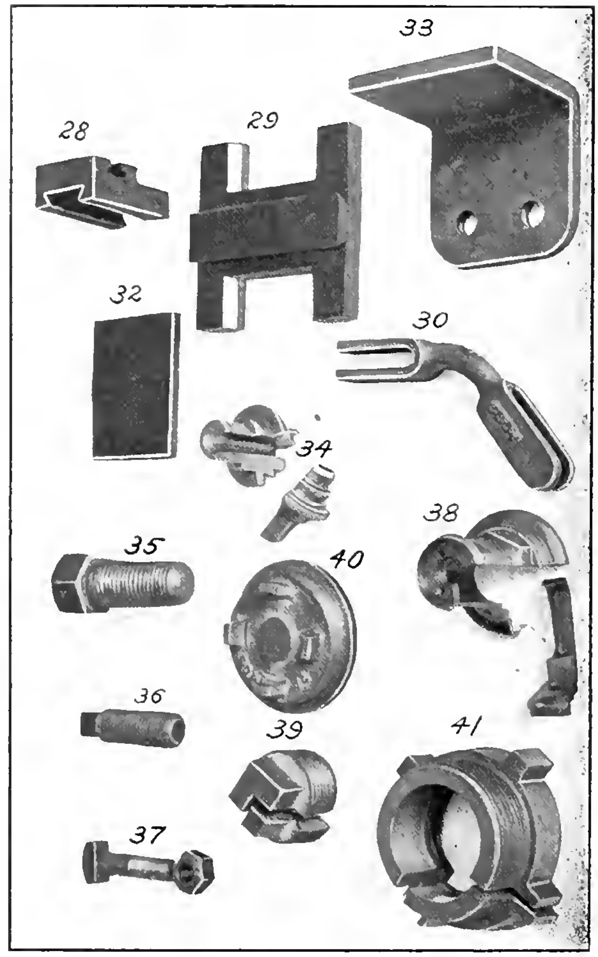


FIG. 15.—NUMBERS INDICATE DRAWING EXERCISE.

but after having thoroughly mastered the simpler principles the student is ready to take up the more difficult problems. This is the first drawing to be made on a T-sheet, which, as may be seen from the general instructions, is 19 x 12 in. in size and is the next size larger than S. In the next twenty-eight exercises four are to be drawn on this larger size sheet.

After exercise seventy-eight (the main rod for the G-5 consolidation locomotives) the various parts which go to make up the complete rod are each taken up in detail, the instruction sheets being similar to that for exercise 78. The next eleven exercises consider the main rod strap; rod brasses; adjusting wedge; adjusting wedge bolt; a taper bolt; adjusting wedge liner; grease cup lug; grease cup cap; grease cup stud and grease cup nut. Exercise ninety, Fig. 30, is an assembled drawing of these parts on the rear end of the main rod and contains a table giving the names of the various details, the pattern numbers for the castings and the number of the drawing upon which each is to be found.

In the same way exercises ninety-one to ninety-five, inclusive, consider the piston, piston rod, packing rings, piston plug and piston rod nut for the Class G locomotives. A partial assembled drawing of these is the subject for exercise ninety-six. The instruction sheets are similar to those for the main rod series.

Similarly the next nine exercises cover the back cylinder head, packing gland, and the details of the metallic packing. Exercise one hundred and six is an assembled drawing of the metallic packing.

This is as far as the course has been arranged, but additional exercises are being prepared, and it is the intention to have it include complete drawings of the Class G engines.

CAR AND BOILER DEPARTMENT COURSES.

The car and boiler department courses have not been developed to the extent that the locomotive course has, since the earlier exercises in that course are equally well adapted for the other two. A number of exercises have been arranged for the car department apprentices which consider parts that are only used in the car department, and additional ones will be arranged as they are needed.

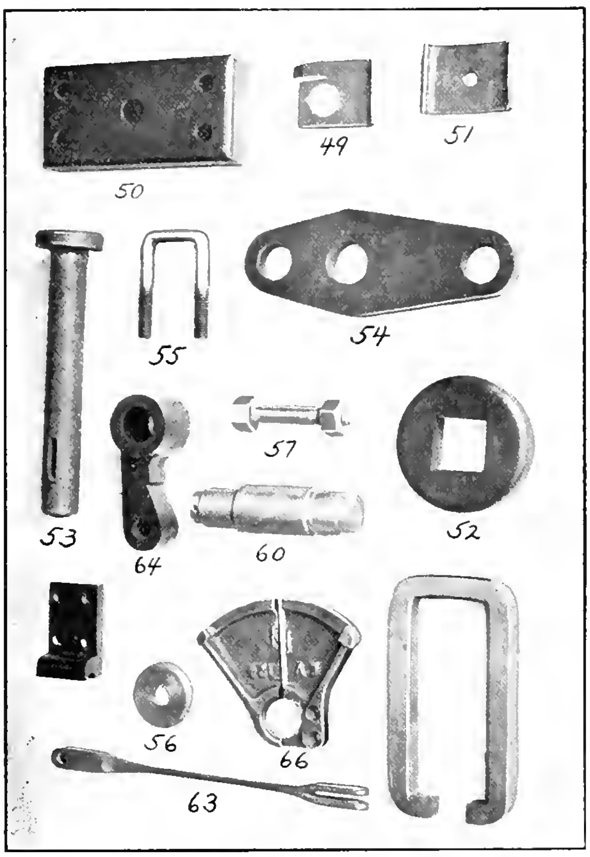


FIG. 16.—NUMBERS INDICATE DRAWING EXERCISE.

A large number of exercises have been prepared, or are in preparation, for the boiler department apprentices. These consider various problems in laying out sheets and at some of the schools they are being worked out by all of the apprentices. The apprentices are required to lay out about one in every seven of these to full size on wrapping paper. The boys are also detailed to assist the "layer out" in connection with his work in the shop. This is especially true at the Jackson shops.

TRACING.

The boys do not start tracing until they have made at least fifty or sixty drawings and then they only make an occasional tracing. Quite often they are given regular work to do, such as tracing drawings which have been made by the shop draftsman, or tracing foreign prints.

MAKING BLUE PRINTS.

Each school is now being equipped with a frame and tank for making blue prints so that the boys may receive instruction in this and make their own prints.

EXAMINATION OF DRAWINGS BY INSTRUCTOR.

In checking the drawings the instructor not only checks for accuracy, but questions the boy as to the relation of the views, or other matters, to make sure that he has a clear understanding of what he has done. Very often apprentices who are more advanced are called upon to assist the instructor in checking the

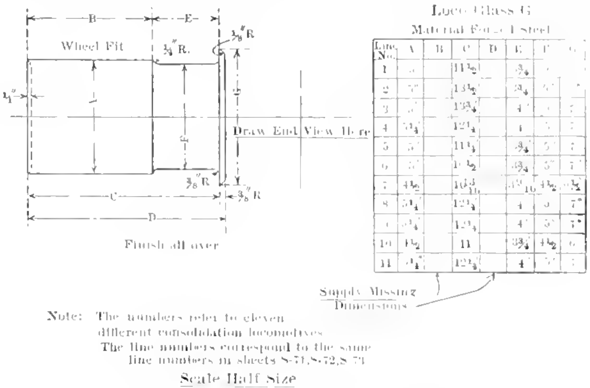


FIG. 28.—DRAWING EXERCISE SEVENTY.

drawings or instructing those who are not as far advanced. This not only assists the instructor, but is splendid training for the apprentice.

The instructor keeps the drawings on file and returns them to the apprentices in lots of fifty, bound in blue print covers, and they then become their property.

The Problem Courses.

The previous educational training of the boys who enroll as apprentices varies so much, some of them having not even re-

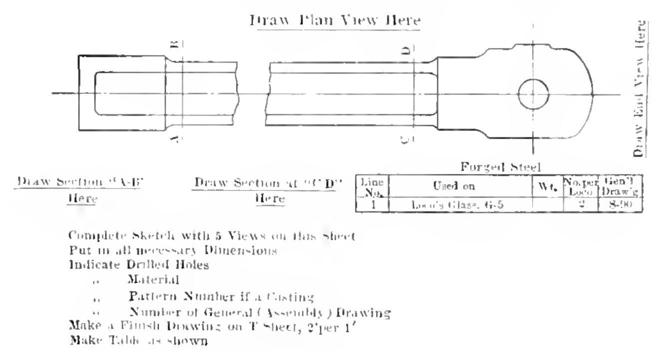


FIG. 29.—DRAWING EXERCISE SEVENTY-EIGHT.

ceived a complete grade school education, while others are high school graduates, that it is necessary to provide an arrangement which will permit of individual instruction and yet not overload the instructor with too much work. It might be well at

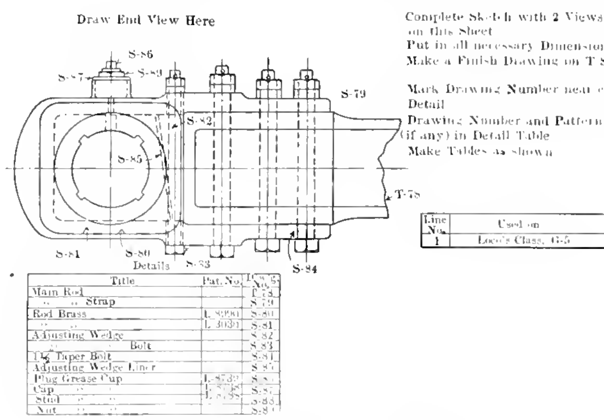


FIG. 30.—DRAWING EXERCISE NINETY.

this point to again emphasize the fact that there is no fixed amount of work which must be done by each student, but the courses are arranged to give the slower and less apt students a thorough training in such mathematics as are needed to meet every-day shop problems, and also so that the brighter and more

ambitious boys may advance as far as their abilities will permit. "The results expected are men and not the covering of prescribed courses or the attainment of arbitrary standards." The instructor is in such close personal touch with each apprentice that he can readily determine as to whether the student is doing his best and making an earnest effort to progress. The drawing and class work mark is based on the apprentice's attitude toward his studies as well as on the quantity and quality of the work done.

General Instructions.

The problems are prepared in New York and are mimeographed on loose sheets, which are sent to the various schools. These problems are to be worked out at home on the student's own time. The apprentice is given the first problem sheet and a copy of the following instructions as to how the solutions are to be handed in.

RULES FOR WORKING PROBLEMS.

1. Use only the standard size sheet, 5½ x 8½ in.
2. Do all work in ink.
3. Rule a margin line ¾ in. from left side of sheet.
4. Place the number of the problem in this margin, but do not re-copy the problem.
5. Print the name in the upper right hand corner of each sheet with letters ⅛ in. high.
6. Arrange the work neatly and mark the answer.
7. The signs used in correcting papers will be a check for correct results, and an X for work that is wrong.
8. Questions marked X should be corrected and handed in again.
9. When several sheets are handed in at one time they should be fastened together.
10. Marks will be based on the ability of the apprentice to work out by himself practical problems like those given for home work, and handing in correct answers will not alone count for a clear record unless similar problems can be readily worked.
11. After corrections have been made the home work will be returned to the apprentices, who will keep the sheets for reference.

When the solutions for one problem sheet are turned in the apprentice is furnished with the next sheet. The instructor keeps a record of the sheets which have been assigned and handed in, and follows the progress of each student closely. The solutions are retained by the instructor until the greater part of the class has covered the ground and are then returned to the students and become their property.

The Courses in General.

The problems are not of the abstract numerical kind, but are such as are met with in the shops and drafting room, being clothed in the language of the shop. They are not classified as to subjects, as in text books; they are, of course, carefully selected and arranged, but this appears only after careful examination. The first ones are simple problems in addition, subtraction, multiplication and division, these four subjects being mixed indiscriminately. They gradually become more difficult, taking up the different branches of mathematics, one at a time, but in such a way that the student hardly realizes that he is starting a new subject. In place of first stating the underlying law in abstract, and then giving an illustration, the problem is first stated and solved, and afterwards, if necessary, a law or rule is given. The student is required to work out a sufficient number of problems, of a similar nature, to make the idea take root from the fact of applying and using it. A running review is kept up constantly, as in the drawing course, by introducing problems which bring in points which were previously covered. The interest of the student is stimulated by varying the standard of difficulty and mixing the easy with the hard problems, as they are apt to come in practice.

Occasionally the instructor has the students go to the blackboard during the school session and assigns them different problems. This gives him an opportunity of finding whether they understand thoroughly the work which they have done on the problems and of pointing out errors and rubbing in any principles that are needed.

Two sets of problem courses are now in use, one for the locomotive department and the other for the car department; the problems in both these courses are quite similar, except that those which are distinctively locomotive problems have been omitted and replaced in the course for the car department. The problems, as far as possible, are based on actual figures which are taken from the company's drawings, standards or records; from facts and data which have appeared in the technical press; from suggestions of motive power officers; problems directly from the shop drafting room; hints from the instructors and points which may have come up in conversation with the foremen and mechanics. Each student is furnished with a copy of "Machine Shop Arithmetic," by Colvin, and frequent references are made to this in connection with the different problems, which makes it necessary for the student to refer to it and encourages him in making use of it.

The Locomotive Course in Detail.

The principles which have been followed in arranging these courses can best be illustrated by presenting a number of typical problems which have been selected from the course for the locomotive department.

3. If 6 castings weigh as follows, what is the total weight? 336 lbs., 403 lbs., 210 lbs., 357 lbs., 416 lbs., and 428 lbs.

Although the first problems are very simple they are stated in terms of the shop, and not in abstract, thus at once gaining the interest of the apprentice by giving him a practical application of the principles involved.

Problem. If the same job was divided equally among 25 men, how many even hours would each man work, and how much overtime would one man of the number have to put in to complete the job? Divide the time (377 hours) by 25, and the remainder will be the overtime required for one man.

```
25)377(15
   25
   ---
   127
   125
   ---
     2
```

15 hours for each man.
2 hours overtime for one man. *Answer.*

When the problem courses were first arranged, special instruction sheets were inserted illustrating the application of new principles, as they were introduced. In revising the course it has been found advisable to discontinue this and as new principles come up, to present solutions of problems, in which they are involved, on the problem sheets themselves, as above.

9. If a casting can be machined at a cost of 67c., what will be the cost of machine work at the same rate on 9,726 duplicate pieces?
Multiply 67 × 9726.
Change from cents to dollars and cents.

In the above case the notation explains the steps which are to be taken to obtain the solution, but leaves the actual work of obtaining it to the student himself.

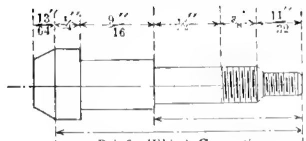
Ten Wheel Locomotive

23. A ten wheel locomotive has a weight of 47,026 lbs. on each pair of drivers and 20,850 lbs. on each pair of truck wheels. Find the weight of the engine.

In revising the problem courses it has been found advisable to use diagrams or sketches in connection with some of the problems to make them clearer and more interesting to the students. This will probably be done to a much greater extent as the courses are revised from time to time.

26. What is the footing of a pay roll per month, which shows 4,537 men each averaging 209 hours at a 29c. rate?
45. Find the weight of a round wrought iron bar 2 5/16 in. in diameter and 9 ft. 6 in. long, if a piece 1 ft. long weighs 14 lbs.?
53. An order for cars is divided among four shops according to their capacity. At the end of three months the first shop has completed 1/10 of the entire order, the second shop 2/7, the third shop 1/5 and the fourth shop 3/10. What part of the entire order is completed?
Add 1/10, 2/7, 1/5 and 3/10.
70 is a common denominator as it can be divided by 10, 7 and 5.
1/10 = 7/70, 2/7 = 20/70, 1/5 = 14/70, 3/10 = 21/70.

A brief note preceded the first problems in fractions, telling what they were and presenting the solution of an example in the addition of fractions. Similar notes and illustrations occur at intervals concerning the subtraction, multiplication and division of fractions. The note in connection with the above problem illustrates the method of reducing fractions to a common denominator.



Bolt for Whistle Connections

55. Supply the "over all" dimensions for the bolt shown in the sketch.

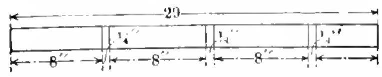
Another illustration of the use of sketches in connection with the problems.

56. A drawing is to have two views placed one above the other. The upper view is 2 3/16 in. high and the lower view 1 9/16 in. high and there is to be ½ in. between the views. If the space inside the margin of the drawing is 8 in. and the work is to be placed centrally on the sheet, how far down will the upper line of the upper view be placed? Show location by a sketch.

Note that the student is here required to present a sketch in connection with the solution of the problem.

61. The total weight of a 12 wheel passenger coach without passengers, but with equipment for electric lighting, is 107,980 lbs. 1/33 of this weight is due to the addition of the electric light equipment; what was the weight on each pair of wheels before electric lights were added?

64. A private car weighs 55 tons. A sleeping car weighs 10/11 of the weight of a private car. A 60 foot passenger coach weighs 9/10 of the weight of a sleeping car. A pay car weighs 8/9 of the weight of a 60 foot passenger coach, and a milk car weighs ¾ of the weight of a pay car. Find the weight in lbs. of the sleeper, passenger coach, pay car and milk car.



75. How many 8 in. pieces can be cut from a piece of stock 29 in. long and how many inches will be left if ¼ in. is wasted per cut?

90. A tender loaded weighs 111,000 lbs. Its capacity is 10 tons of coal and 5,000 gallons of water. What would be its weight with 6 tons of coal and the tank 2/5 filled?

121. If a locomotive burns 1,200 lbs. of coal per hour when going at a rate of 18 miles per hour, how many tons of coal will be burned in going 99 miles at the above speed?

129. What is meant by a Prairie type locomotive? (Type J New York Central). Sketch diagram of wheels.

In each school room a blue print is posted showing the classification of locomotives according to the arrangement of the wheels.

145. With shops running from 6.30 A. M. to 5.15 P. M., with ¾ of an hour for lunch, what would be the day's wage of a boy at 12½c. per hour?

149. What is the weight of a 7 in. channel 10 ft. long when the weight per foot is 1.75 lbs.?

Problem. A lot of screws weigh 69.3 lbs. What will 1/10 of the lot weigh? 6.93 lbs. Answer.

To divide by 10, move the point one place to the left.

163. If a bolt heading machine has the following daily output for one week, what is the total amount to be paid the operator for his week's work at the rate of 13c. for 100 such bolts? 2330, 2060, 1950, 2420, 2310 and 2030?

166. A N. Y. C. tender frame is constructed with four 13 in. steel channels, each 25 ft. 9 in. long, weighing 40 lbs. per foot. Find the weight of steel channels needed for 18 frames.

188. A locomotive is to be extended 3 feet in order to gain heating surface and thus increase the steaming capacity. If there are 375 2 in. tubes, No. 11 gauge, how many sq. ft. of heating surface will be gained in the tubes? For the sq. ft. of heating surface per foot of tube length see drawing plate S-44.

(Note: Heating surface is based on the outside surface of tubes.)

An example of how the problem and drawing courses are "tied together." Several illustrations of this will be found among the following problems.

202. If a planer makes a cutting stroke of 12 ft. in 20 seconds, what is the cutting speed of the tool in feet per minute?

204. A tank requires a plate which measures 8 ft. 10 in. long and 4 ft. 5½ in. wide. How would these dimensions look when placed on the drawing?

(See Rule 14 of drawing instruction sheet posted in class room.)

208. Show by sketch the difference between a box car and a gondola car. Draw only an outline and do not show details.

215. The time between two mile posts is 74.6 seconds; what is the speed in miles per hour?

220. What steam pressure do locomotives now use? Tell where you get your information.

229. A micrometer caliper shows a piece to have a diameter of .678 of an inch. What would be the diameter expressed in the nearest sixteenth of an inch?

235. A blacksmith shop has a floor area of 37,026 sq. ft. If the width is 102 ft., find the length.

247. Find the weight of 25 sheets of ⅛ in. brass, each sheet measuring 16½ in. x 24 in.

(See problem 123.)

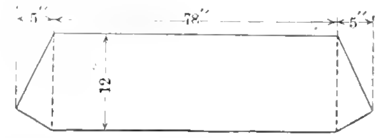
258. Show by a sketch what is meant by a crowned pulley.

259. Why are some pulleys crowned and some straight?

265. On a consolidation locomotive (Type G, New York Central Lines) (See drawing S70-73) how are the driving wheels usually named? Place the names on a sketch like that shown on the blue print of locomotive classification. Also show which wheel the main rod connects with.

The above reference refers to the drawing course.

271. Find the number of sq. ft. in a roll of canvas 6 ft. 6 in. wide and 36 ft. 8 in. long.



294. Find the area of this ash pan side by dividing it into two triangles and one rectangle. Add the three areas. The area of the left hand triangle is ½ x 12 x 5.

315. What is meant by a 4¼ x 8 in. journal? Show by sketch which dimension is the diameter. See drawing plate S77.

361. From a sheet of Russian iron 8 ft. square, how many pieces 2 ft. square can be cut. Sketch the sheet and show cutting lines.

In finding the areas of circles in the following problems use table on page 137, "Machine Shop Arithmetic."

367. Three oil cans are the same height, two are 10 in. in diameter and the third 15 in. in diameter. Will the 15 in. can hold more or less than the two others combined. (Compare the areas and show figures.)

395. A bar has a tensile strength of 70,000 lbs. per sq. in. Is it steel or wrought iron? Page 46, "Machine Shop Arithmetic."

Preceding problem 401 is a note to the effect that the areas in the following problems are to be worked out.

404. Find the total pressure tending to blow the head out of an air drum 16½in inside diameter with 90 lbs. per sq. inch air pressure shown by gauge.

421. What would be the pressure on the entire piston of a 10 in. brake cylinder of a passenger coach in an emergency stop with a quick action valve, if the cylinder pressure is considered as 60 lbs. per sq. inch?

Preceding the introduction of percentage is a short explanation of what it is, together with a few typical examples showing how such problems are solved.

429. If a passenger coach with passengers weighs 94,950 lbs. and the passengers weigh 4,500 lbs., what per cent. is the weight of the passengers of the total weight?

432. A drum head 21 in. in diameter is cut from a sheet of ⅜ in. plate 22 in. square. What is the weight of steel cut off? (⅜ in. plate weighs 15.3 lbs. per sq. foot.)

433. In the last problem, what per cent. of the entire metal was wasted?

450. An axle originally weighs 1,038 lbs., and loses 6½ per cent. when turned. What is the final weight? (Nearest pound.)

457. Four groups of men are being paid at the following hourly rates: 23c., 25c., 27c. and 30c. If the pay of each group is increased 2c. an hour, what is the per cent. of increase?

461. A Pittsburgh & Lake Erie Class C locomotive with an Alfree-Hubbell valve has a piston displacement of 7,372 cubic inches. Find the cylinder clearance volume in cubic inches if it is 2.4 per cent. of the piston displacement.

471. If enclosed Pintsch lamps consume ⅝ of a cubic foot per hour for each burner and open burners consume 1 cubic foot per hour, how many cubic feet of gas will be used during 7 hours on a sleeping car with 9 enclosed lamps of 4 burners each, 3 enclosed lamps of 2 burners each, and 4 single open burners?

474. A machinist apprentice planing wedges cuts ½ in. stock from each. If the surface cut measures 5½ in. x 9½ in. what is the weight of cast iron removed from 40 wedges?

For weight of cast iron, steel and wrought iron see page 46 "Machine Shop Arithmetic."

487. Find the weight of a hollow cast iron column 14 ft. long, 10 x 12 in. outside, and ¾ in. thick. Add 75 lbs. for weight of cap and base.

496. Obtain a square bar of wrought iron from the instructor; take its dimensions and figure out the weight at home. Weigh piece at next class and hand in both results with a dimensioned sketch.

505. A 38 ft. tank car has a tank 93 in. inside diameter and 34 ft. long. What is its capacity in gallons?

522. Find the piston displacement, both front and back ends of the following locomotive cylinders:
20½ x 26 in. with 3¾ in. piston rod.
24 x 28 in. with 4¼ in. piston rod.

544. On a 36 in. planer at West Albany the ratio of the cutting speed to the return speed of the table may be as 1 to 2.94. With a cutting speed of 50 ft. per minute what is the return speed? (A ratio of cutting speed to return speed of 1 to 2.5 would mean that return speed was 2.5 times the cutting speed.)

546. The netting in the front end of a locomotive is made of wire marked No. 11 B. W. G. What is meant by B. W. G., and what is the diameter of the wire? (See blue print posted in class room.)

547. A Class F locomotive has a netting in the smoke box 24 x 24 in. made of wire marked No. 11 B. W. G. with a 2½ x 2½ in. mesh. How much space in square inches is open for the passage of smoke and cinders and how much is taken up by the wire itself? (By 2½ in. mesh is meant that there are 2½ wires to each inch.) Ans.: Open 282 sq. in., wire 294 sq. in.

562. In setting valves without a valve setting machine on a G-5 locomotive, it is necessary to find centers by "pinching" and to give the driving wheels at least one complete turn. The locomotive has a total wheel base of 25 ft. 11 in. and 63 in. drivers. How long a piece of track must be available for the job?

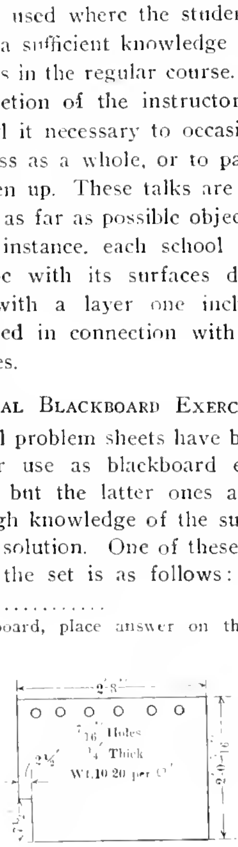
In connection with the course, as outlined above, several extra sheets have been provided containing problems which are to be used where the student does not seem to have gained a sufficient knowledge of the subject from the problems in the regular course. These are assigned at the discretion of the instructor.

The instructors find it necessary to occasionally give short talks to the class as a whole, or to part of it, as new subjects are taken up. These talks are short, simple and informal and as far as possible objects are used as illustrations; for instance, each school is provided with a one-foot cube with its surfaces divided into square inches and with a layer one inch thick removable. This is used in connection with the introduction of the subject of volumes.

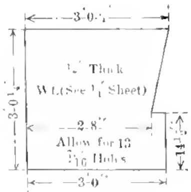
Special Blackboard Exercises.

A number of special problem sheets have been arranged, on the subject of areas, for use as blackboard exercises. The first problems are simple, but the latter ones are quite complicated and require a thorough knowledge of the subject, on the part of the student, for their solution. One of these sheets selected from about the middle of the set is as follows:

Name........................ Date.............
Do work on blackboard, place answer on this sheet and return to instructor.



Find weight of this side sheet.
Area of large rectangle.
Area of small rectangle.
Area one 7/16 in. hole.
Area of sheet.
Weight of sheet. Answer.

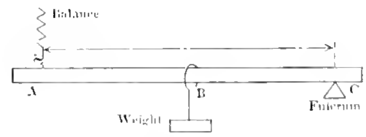


Find weight of side sheet. Answer.

Experimental Work.

In addition to the main problem courses, such as outlined, two supplementary sets of problem sheets have been provided, dealing with experimental work which is carried on during the school sessions. One of these covers the subject of levers, the other valve setting.

Levers.—The apparatus shown in the accompanying drawing and a small fisherman's tubular balance are used with the lever problems. These experiments are worked out by two boys at a time. The first sheet in the series is as follows:



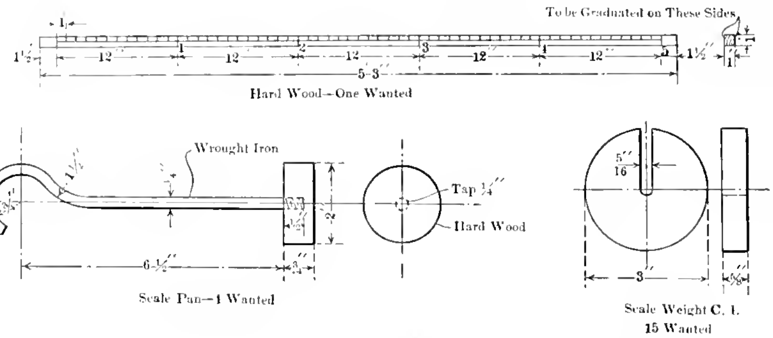
Obtain a light stick, rest one end on a block as a fulcrum and hold up the opposite end of the stick by a spring balance.

5a. Hang a weight of 6 lbs., 5 in. from the fulcrum. Read the spring balance. Notice that the stick tends to turn down on account of the weight and that the balance tends to turn it up about the fulcrum. The weight X its distance from the fulcrum (6 x 5) is called the "moment" of the weight about the fulcrum. The balance pull × its distance from the fulcrum is called the "moment" of the balance pull and this moment is equal to the moment of the weight, otherwise the stick will turn either up or down. A moment is always found by multiplying a force by an arm or distance, and the arm or distance is always at right angles to the force.

In this case multiply the reading of the balance by its arm 30 and see if this moment is equal to the moment of the weight (6 × 5).

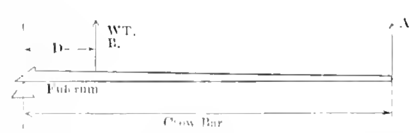
The answer should include the following:
Reading of balance = ?
Moment of balance = ? × 30 = ?
Moment of weight = 6 × 5 = ?

Note.—The reading of the balance is the difference between what it reads before the weight is put on and after. This is because balances do not always read zero at start and also because the stick will show some weight. For example, if the balance reads 1¼ lbs. holding stick alone and shows 2¾ lbs. when the weight is added, the scale reading due to the weight would then be the difference between these weights or the increase in the reading, 2¾ — 1¼ = 1½ lbs.



APPARATUS USED IN CONNECTION WITH LEVER EXPERIMENTS.

After a number of problems of this type have been worked out and checked experimentally, practical applications are considered such as a forge crane, crowbar, belt shifter, reverse lever rigging, throttle lever, foundation brake gear and track scales. A few problems in connection with the crowbar and throttle lever are as follows:



19. If a casting of 100 lbs. weight is to be lifted at B, and if d is 3 in., how much pull will be required at A? Make a sketch with dimensions.

20. If the casting at B weighs 100 lbs. and d is 6 in., what will be the pull at A? Make sketch.

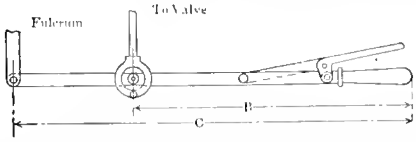
21. If an iron bar at B weighs 560 lbs. and d is 3 in., what is the pull required at A to lift the bar? Sketch.

22. Which will move further when the weight is lifted in problem 9, point A or point B?

23. With d equal to 9 in. and B equal to 230 lbs., what is the pull required at A? Sketch.

24. What would be the pull in the above problem if the bar was only 4 ft. long instead of 6 ft.?

55. A locomotive is fitted with a throttle lever, like that illustrated, where C is 46 in. and b is 40 in. If the throttle lever stem (marked "to valve") is to have a motion of 1¾ in. how far will the end of the handle move?



56. The above engine is to be used for switching, but it is found that the throttle lever is too short to enable the engineer to see the switch signals and still have hold of the lever. If the handle is made 8 in. longer to bring it within the engineer's reach, how much must the fulcrum be moved to give the end of the handle the same motion as at first?

57. If C is 42½ in. and B is 37 in., how far will the end of the handle move when the throttle lever stem moves 2 in.?

Valve Setting.—The small vertical engine, with which each school is furnished, is used in connection with the special problems on valve setting. The first problems or experiments are such as to familiarize the student with the different parts of the engine. The first ten problems are as follows:

VALVE SETTING.

Take the following measurements from the small slide valve engine in the class room and fill in on this sheet—leave this sheet with the instructor. Apprentices will work in groups of two. If engine is provided with link motion place it in full gear forward.

1. Diameter of cylinder—carefully remove top cylinder head. ....in.
2. Length of stroke—do not scratch the guides—use chalk or pencil, or paste on a slip of paper. ......in.
3. Diameter of piston rod. ......in.
4. Length of crank, center to center—from center of crank pin to center of shaft—½ of stroke. ......in.
5. Length of connecting rod (main rod) center to center. Do not take out rod. ......in.
6. Diameter of valve stem. ......in.
7. Total valve travel—the distance that a point on the valve moves ......in.
8. Eccentricity, the distance from the center of eccentric to the center of the shaft—½ valve travel. ......in.
9. If an engine has a stroke of 28 in., what is the distance from the center of the crank pin to the center of the shaft?
10. An eccentric is set with its center 2 in. from the center of the shaft. What is the greatest movement of the valve?

These problems gradually become more difficult and the student is finally asked to set the valves without assistance. Explanatory notes are introduced as found necessary. An idea of the nature of some of the more advanced problems may be obtained from the following, which is taken from one of the later sheets.

Note.—The LEAD is the amount the valve has opened the steam port when the engine is on the center. A valve with ¼ in. lead means that when the engine is on center the valve is open exactly ¼ in. The amount of lead depends on the type of engine and the speed it is to run. The proper lead gives a cushion of steam to the piston and also insures a high effective pressure on the piston early in the stroke.

36. Set the engine in the class room with an equal lead of 1/16 in. at each end. Instructor's O. K..........
37. After instructor has changed eccentric and valve stem, set the valve to give ⅛ in. lead at each end. Instructors O. K.......
38. Turn the engine over slowly and measure the largest opening of the steam port at each end. This is called the port opening. Top..........in. Bottom..........in.
39. Does the valve uncover the port its full width? Find out by turning the engine slowly. ....
40. In the ordinary locomotive fitted with a slide valve, is the space around the valve filled with steam or is it connected with the exhaust? ....

It is proposed after the students have become thoroughly familiar with the working of the small vertical engine, to give them problems concerning the valve motion of the locomotive, and finally to take a light engine out on the track and have the boys set the valves, pinching it back and forth. After they have thoroughly mastered this they will be taken into the shop and taught to set valves in accordance with the standard shop practice. Models of the application of the Walschaert valve gear are being built for the different schools, to be used with this part of the course.

Comments.

It must be kept in mind that the work of the drawing and problem courses, which has been described, is such as would be covered by the average student in a year or year and a half. It will be some considerable time before the courses are finally completed. Some of the boys not having a bent along these lines, but who may make splendid mechanics, will not advance very far. On the other hand, there are sure to be a number of the brighter boys who at the close of the four-year course will have advanced to a very high point. The reader who has followed thus far will undoubtedly be impressed with the practical way in which the educational work is taught, and the fact that although a great many things may have been omitted, which are usually included in the school curriculum, the apprentice has been given a thorough training in those things which will be of practical value to him in connection with his work.

Instructions to Drawing Instructors.

The following instructions to the drawing instructors, concerning the class work, forms a fitting conclusion for this section of the article and will be of interest.

1. Know personally every student in your class and make yourself familiar with his disposition, ability and ambitions.
2. Make all the work which you give out center around a practical problem, and not around the statement of some abstract law. For example—It is a fact that the product of (1) the revolutions per minute that a wheel is turning and (2) the circumference of the wheel in feet will equal the speed of the rim in feet per minute, but this would be more easily understood from the following problem: If a pulley 4 ft. in diameter turns 200 times a minute, how fast is the rim moving? $200 \times 4 \times 3.14 = 2{,}512$ ft. per minute. The idea is thus made definite and explanations and rules naturally follow.
3. Never omit any steps, however simple, in solutions or explanations. If there is one little point about which a student is confused in the early part of the problem, he is sure to miss what follows.
4. Put yourself in the student's place, look at the problem from his standpoint, and do not expect him to grasp instantly that which has taken you years to acquire.
5. While the instruction is in some measure individual, it should be possible to take up many subjects with the class as a whole or with groups. This will save time and effort for the instructor and will create more interest among the students.
6. Make class-room work take the form of explanations and illustrations rather than that of lectures. Encourage questions and make every effort to get the classes as informal and easy as possible. Have something "up your sleeve" for emergencies—extra problems to spring when needed. Never allow the work to drag. Maintain an enthusiastic, brisk, off-hand manner, which will do much to create a wide-awake, business-like attitude on the part of the students. Keep the men busy and good discipline will follow.
7. Encourage students wherever particular advancement is evident. Some men require commendation.
8. Be patient. The slowest men sometimes develop into the strongest.
9. Maintain sufficient assurance at all times to be "boss" of the class. Your decision must always decide, although, of course, you will welcome and profit by suggestions from the class.
10. Do not ask too much of the class, but insist to the letter on whatever you do ask.
11. Do the work thoroughly. It is much more important than to cover a number of subjects superficially.
12. Encourage students to keep note books for the collection of useful information, and to read technical literature.
13. Wherever possible make use of a simple illustration—a picture, a model or a machine part?
14. Strive to make your classes so intensely interesting that students will forget that the attendance is compulsory, and will study because they like it, and not because they have to.

Apprentice vs. Technical School Training.

There seems to be a strong feeling in some quarters to the effect that these two systems are opposed to one another. This is not true; while their final object in one sense is the same—to make men—the material upon which they are to work and the results they hope to accomplish are very different. When we consider the poor manner in which the greater proportion of technical graduates have been equipped for going into practical work, and the serious mistake made in the past by railroads of labeling the college graduate with a title of "special apprentice," and at the same time practically serving notice upon the rank and file that the higher positions were closed to them, and lastly the fact that the provisions for training the regular apprentices have been, as a rule, entirely inadequate for recruiting the ranks or properly fitting the men for their work, it is little wonder that now that the railroads are at last beginning to realize the grave importance of remedying their mistakes in this respect, that the above question should be brought up.

In the first place the technical school does not and cannot undertake the training of the mechanic. Trade schools have been introduced in some parts of the country, but the conditions and requirements of the various manufacturing industries are so different that it is doubtful if the value of such schools can be fully appreciated, except in places where the interest of the community centers about one or two different kinds of industry, and where the schools are operated in close conjunction with industrial works.

Manifestly the only place to train the railroad mechanic properly is in the railroad shop. The large number of railroads (and manufacturing concerns as well) which are investigating the New York Central methods and the fact that several railroads have under way elaborate plans for educating their shop employees argues well for the future, and it is to be sincerely hoped that such work will not stop here, but will be extended to all branches and departments of our railroads.

There should, however, be a close relationship between the apprentice schools and the technical schools. The great defect in our present system is that many of the boys and young men entering our technical schools have only a very vague idea as to what engineering is, or as to what their future work will be. They have simply gathered in a general way that it is a good thing to be a mechanical engineer, an electrical engineer or some other kind of an engineer. How can a technical school divorced from all practical work, and many of whose professors and instructors have only a remote idea concerning the practical application of their engineering knowledge, expect to prepare such men for practical work? You call attention to their magnificent shops and well equipped laboratories, but there is just about as much difference between such shops and laboratories and the ordinary work-shop as there is between light and darkness. You say that they learn to test engines, boilers, etc. Yes, but what if something should go wrong with the engine or boiler, can they fix it, or have they any idea how to take it apart, and put it together again? After finishing a test of a condenser, have they any idea as to what it looks like inside, or how a leak can be stopped? When our technical schools are placed in the hands of practical engineers maybe this will be so, but except to a limited extent it is not true at present.

Some of the more progressive professors have tried to insist that their engineering students spend a part of their summer vacations, at least, in work-shops and this has done much to improve conditions. The practical and common sense method, however, would be to have the learning of the practical work and the gaining of theoretical knowledge go hand in hand. The apprentice school does this to a certain extent and the proper time for the boy to enter a technical school is after he has completed, or partially completed, such an apprenticeship. Many young men are wasting their time at our technical schools who are totally unfitted for engineering work. An apprentice course would serve to weed out those who are not qualified to follow up such work and those who show aptitude for it could take a special finishing course at a technical school and would then prove far more valuable to the railroads than those who have taken a technical course but have had no practical work. As far as the gaining of purely engineering knowledge is concerned the apprentice school can, of course, be only a small factor as this is the real function of the technical school.

[EDITOR'S NOTE.—Since the series of articles on the New York Central Lines apprentice system was first planned, certain important developments have taken place making it advisable for us to add another section, which we expect to publish in our November issue. See editorial in this issue.]

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The first monthly meeting of the year will be held on Tuesday evening, October 8, in the Engineering Societies' Building, New York. The subject will be "Industrial Education" and a paper on the "College Technical Courses and Apprenticeship Courses Offered by Manufacturing Establishments" will be presented by Prof. John Price Jackson. Dr. Henry S. Pritchett, president of the Carnegie Foundation and of the Society for the Promotion of Industrial Education, and Prof. Dugald C. Jackson, president of the Society for Promotion of Engineering Education, will deliver addresses.

SHOP EFFICIENCY.

By H. W. JACOBS.*

Considerable attention has recently been given to the various phases of the betterment work on the Santa Fe, the most important of which is that of shop costs with its factors, individual man efficiency as to labor performed and the scientific scheduling of engines through the shop. The paper on this subject presented by Mr. A. Lovell, superintendent of motive power of the Santa Fe, before the recent meeting of the Master Mechanics' Association, attracted considerable attention. As a paper of this kind has limitations as to length, it may not be amiss to supplement, with more extensive illustrations and examples, some phases of the subject, which it was not possible to fully develop in the paper.

The cost problem, while it is helped by the introduction of carefully prepared shop schedules, which are "lived up to," is by no means solved. The problem involves each individual workman and to solve it some method must be adopted that will cause each man to work at his highest average efficiency. This does not mean that he is expected to over-exert himself, but that he is to cut out all unnecessary delays and wastes. The method

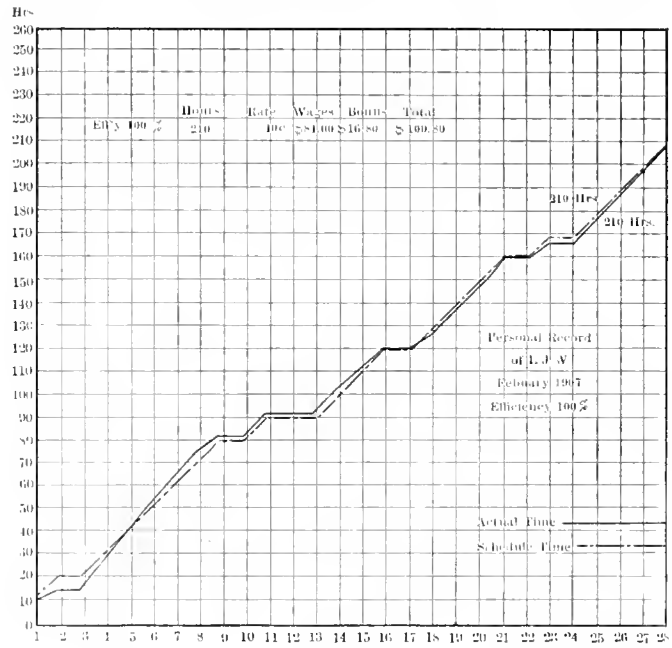


FIG. 1.—INDIVIDUAL EFFICIENCY RECORD OF A GOOD WORKMAN.

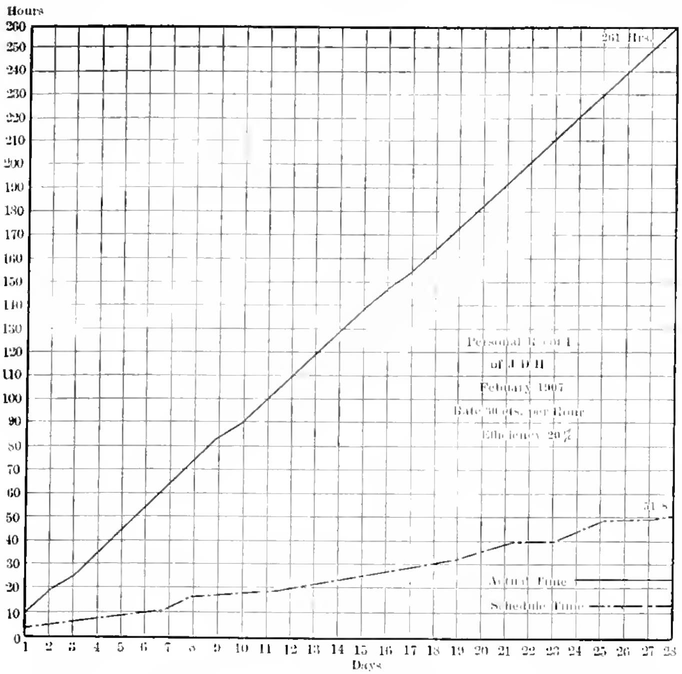
adopted to accomplish this result was the introduction of the individual effort method or bonus system by which each man is able to increase his earnings as he increases his average efficiency.

One very noticeable fact is that the older men are among the highest bonus earners, which is probably due to the fact that they depend to a greater extent upon using their brain power to utilize their available strength, than do the younger men. The accompanying chart, Fig. 1, illustrates the work done by one of the older men in February, and is in several respects ideal. It show the result of steady insistent work, day by day. The full line shows the actual hours worked, which totals 210, while the broken line shows the standard work hours accumulated, which also totals 210, making the man's efficiency for the month 100 per cent. The standard hours are determined by schedules which assign a given time for each operation. The bonus inspector checks up the jobs performed by each man every day and the standard hours accumulated are credited to him.

As an example a lathe operator may have a record as follows:

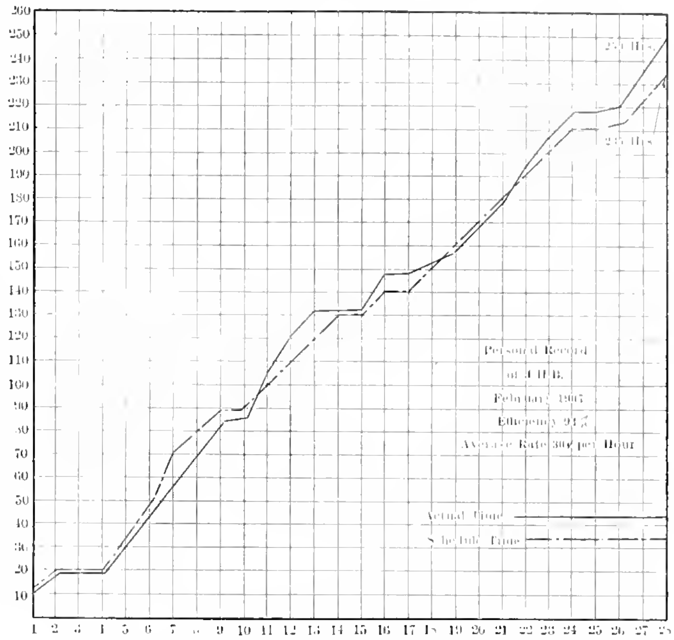
	Standard Time.	Actual Time.
Turn three eccentrics (at 1.3)	3.9	3.3
Turn two small eccentrics (at 1.0)	2.0	1.7
Turn and bore complete six lateral swing castings (at 0.4)	2.4	2.0
Turn and fit complete two knuckle pins (at 1.5)	3.0	3.0
Total	11.3	10.0

* Member American Society of Mechanical Engineers.



Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
20%	261	30c	$78.30	——	$78.30
100%	51.8	30c	15.54	$3.10	18.64
				Loss to Company	$59.66
100%	261	30c	$78.30	$15.66	$93.96
20%	261	30c	78.30	—	78.30
				Loss to Man	$15.66

FIG. 2.—EFFICIENCY RECORD OF A POOR WORKMAN.



Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
94%	250	38c	$95.00	$12.85	$107.85
100%	235	38c	89.30	17.86	107.16
				Loss to Company	$0.69
100%	250	38c	$95.00	$19.00	$114.00
94%	250	38c	95.00	12.85	107.85
				Loss to Man	$6.15

FIG. 4.—EFFICIENCY RECORD OF A SPASMODIC RECORD.

Eleven and three-tenths hours would then be credited to his efficiency account for the day's work.

The following practical example of cost study is taken from one of the shop time cards from which the workman's wages, bonus and personal records are deduced:

TRUING MALLEABLE IRON PISTON HEAD.

Machine No.	0561
Machine Hour Rate	$0.36
Man's Rate	$0.34
Surcharge to Man	90 per cent
Schedule Time	2.2 hours
Actual January Record	2.25 hours

AVERAGE COST OF EACH OPERATION DURING JANUARY.

Wages	$0.765
Surcharge	0.69
Bonus	0.13
Machine Charge	0.81
Total	$2.395

An unusually hard malleable iron piston head was delivered to the operator who at once protested as he saw that there would be no opportunity for earning a bonus. The work was completed in 8.3 hours. The cost of the operation, in detail, was as follows:

Wages	$2.82
Surcharge	2.54
Bonus	0.00
Machine Charge	2.99
Total Cost	$8.35
Cost with Normal Iron	2.39
Loss	$5.96

Total increase of cost due to hard iron 250 per cent.

This piston head was so badly cracked in putting it on the piston rod that it had to be scrapped and the net loss to the company was $18.40, as shown below:

Cost of turning head	$8.35
Cost of labor for putting head on rod	0.18
Surcharge, 45 per cent. of $0.18	0.08
Weight of head, 535 lbs. at $0.025 per lb.	13.38
3 per cent. for handling material	0.41
Total Cost	$22.40
Scrap value at $0.0075 per lb.	4.00
Net Loss	$18.40

Under the efficiency plan it becomes incumbent on the man to register a protest against improper or defective material to protect his own interests and this institutes a close check on the quality of material delivered to the company.

At 100 per cent. efficiency the workman receives a bonus of 20 per cent. of his wages. For example, the man represented in the chart, Fig. 1, has earned 210 times 40c. or $84.00 and a bonus equal to 20 per cent. of this, making his total income for the month $100.80. For efficiencies below 100 per cent. the bonus is taken from efficiency tables, which are calculated from the bonus curve, Fig. 3.

Fig. 2 illustrates the work of a poor workman, his efficiency being only 20 per cent. His wages for 261 hours at 30c. amount-

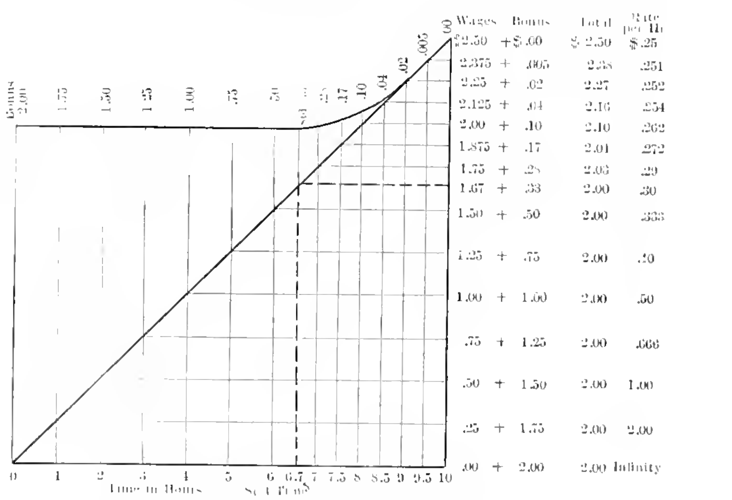


FIG. 3.—CURVE FROM WHICH AMOUNT OF BONUS IS CALCULATED.

ed to $78.30. According to the schedules the man should have done the same amount of work in 51.8 hours, which at 30c. an hour and with the 20 per cent. bonus would have made the total cost to the company $18.64. Due to the inefficient performance of this man the company therefore lost $59.66. If he had attained an efficiency of 100 per cent. in 261 hours he would have had a bonus coming to him of $15.66 in addition to his wages of $78.30, which would have given him a total income of $93.96 for the month. It will be noted that this man worked every Sunday

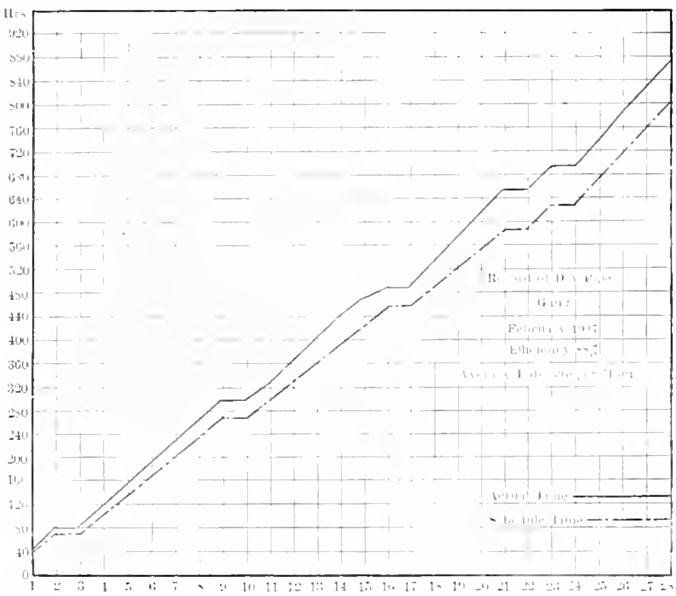
in the month and that he also worked overtime. This undoubtedly had something to do with his low efficiency.

The work of an unsteady and spasmodic workman is illustrated by the diagram in Fig. 4. Such a man can do good work, but is not to be depended upon. If his foreman should want him for a rush job he is very apt to lay off or work at a low efficiency and is apparently of a somewhat emotional nature.

Efficiency charts for the different gangs and departments or for the entire shop are plotted the same as for the individual workers. Fig. 5 shows the work of the dry pipe gang for February, its efficiency for that month being 88 per cent.

The diagram in Fig. 6 shows the efficiency of the repair track for the month of January, during which time there were ten rainy days, the chart distinctly showing the effect of this on the efficiency. During the following month, February, there were less rainy days and the efficiency of the department increased from 72 to 85 per cent.

Fig. 7 shows the efficiency of a shop as a whole. The total number of hours worked during the month was 129,470 and the standard time allowed for performing the various operations was



Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
88%	867	30c	$260.10	$19.16	$279.26
100%	768	30c	230.40	46.08	276.48
				Loss to Company	$2.78
100%	867	30c	$260.10	$52.02	$312.12
88%	867	30c	260.10	19.16	279.26
				Loss to Men	$32.86

FIG. 5.—EFFICIENCY RECORD FOR DRY PIPE GANG.

103,335, so that the shop efficiency was 80 per cent. The first day of the month being New Year's day, no work was done. The second day the men came to work and worked at a high efficiency, probably due to the fact that it was the beginning of the month. At the close of the third day the efficiency dropped off slightly, the week closing at a lower efficiency than at the beginning. The sixth day being Sunday, no work was done.

The second week the workmen began with a high efficiency, however showing slight signs of a decrease at the end of the eighth day and slowly decreasing for the rest of the week. The thirteenth was Sunday and no work was done.

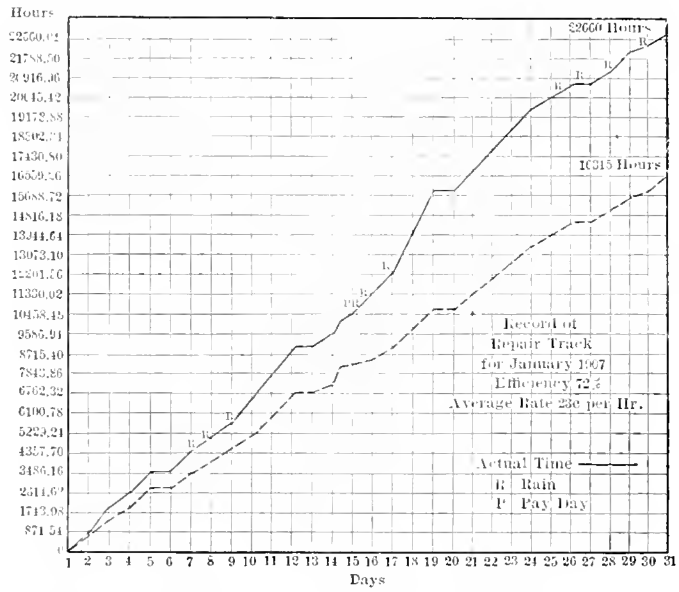
The first two days of the third week the efficiency was high. The effect of pay day, the fifteenth, is shown by the falling off in efficiency on the sixteenth. On the morning of the seventeenth the workmen began to work more efficiently, the week closing, however, showing the bad effect of pay day. The twentieth, Sunday, no work was done. The men began the fourth week with renewed efforts, their efficiency being high for the first day, but the next day it again began to drop, closing the week on the twenty-sixth with a much lower efficiency than any time during the month. The 27th was Sunday. The men worked very efficiently the rest of the month, falling off slightly on the last day.

The labor and bonus cost of scheduled work for the month at 80 per cent. efficiency was $35,505.52, the total bonus paid amounting to $4,006.83. If this same work had been done at 100 per cent. efficiency the labor and bonus cost would have been $29,822.63, including a bonus of $5,006.83, which would have made an increase to the workmen of $1,000 and a reduction in the cost of the work to the company of $5,683.84. This clearly shows that the greater the bonus paid to the men, the cheaper the work becomes to the company.

Results.

Record of Individual Workmen.—Knowing the efficiency of the individual workmen their advancement to positions of greater usefulness can be automatically determined.

Record of Entire Shop.—By setting "Standard Time" on each operation performed by each workman, after expert analysis of conditions, a totaling of standard times for all operations of all men and actual times can be determined, showing the efficiency of each shop department and for the shop as a whole. By thus determining the efficiency of different division shops a much better comparison of the amount of work turned out can be



Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
72%	22,660	23c	$5,109.73	$839.66	$5,949.39
100%	16,315	23c	3,752.45	750.49	3,502.94
				Loss to Company	$2,446.45
100%	22,660	23c	$5,109.73	$1,021.94	$6,131.71
72%	22,660	23c	5,109.73	839.66	5,949.39
				Loss to Men	$182.32

FIG. 6.—EFFICIENCY RECORD OF REPAIR TRACK GANGS.

reached than by the old haphazard method of counting the mere number of engines or cars repaired. This old method is inconclusive owing to there being no set measure of the amount or character of the work done on each car or engine, nor of the condition of the car or engine when received at the shop and when again placed in service. The attempted classifications of character of repairs now in vogue are mostly based on the amount of money spent, with scarcely any reference to amount of work done. Such methods tend to show for the shop with poor organization and high and inefficient labor costs, a more creditable output than that of a shop with good administration and low and efficient labor costs.

By having centralized supervision of detailed operation costs at each shop, it is mathematically practicable to determine the shop where each class of work can be most efficiently performed, and the methods of the efficient shops can be applied to the places whose practice needs improvement.

The system as outlined has reduced the cost of repairs, raised the pay of the workmen and established the output of the shops.

It is a task in itself to urge and develop practically such methods. It is a greater task to convert others into sympathy and co-operation with new ideas so that the workmen will not feel that it is a scheme to get something from them for nothing and

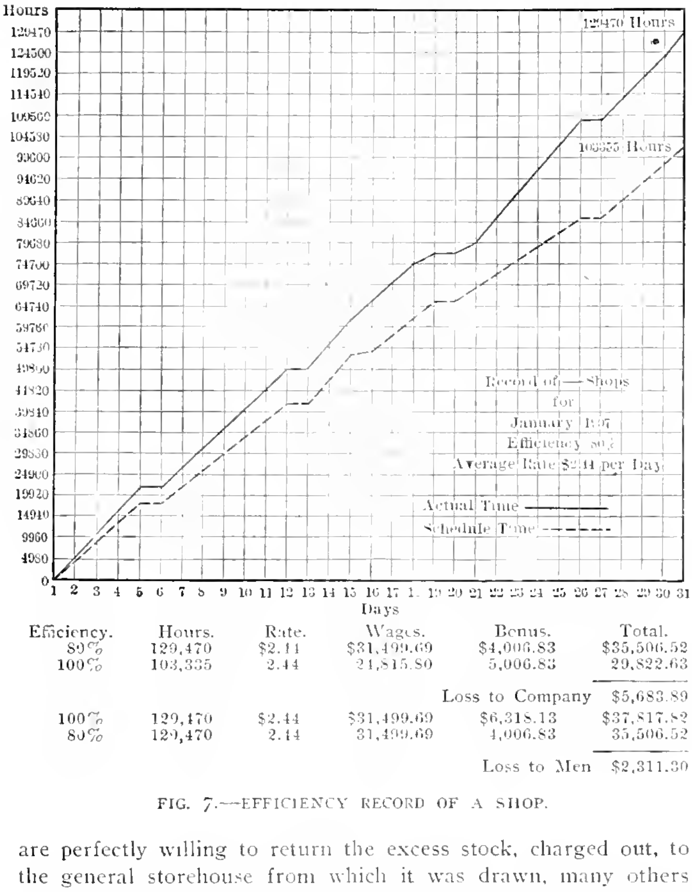
to take away their liberty, but that they may be brought to realize that while the plan helps the railroad it also helps the workmen in a fair proportion.

SHOULD THE JURISDICTION OF THE STOREKEEPER EXTEND TO THE TIME THE MATERIAL IS ACTUALLY USED.*

By H. A. Anderson.†

This subject is one which in a measure interests all departments of a railroad and more especially the motive power and roadway departments. These two departments consume practically 95 per cent. of the material and on a large railroad where the amount handled and charged to closed accounts may represent as much as five million dollars per month, it is obvious that more or less of the material drawn from stock will be left over, due to the fact that it is impossible in all cases to estimate exactly just what amount of each item will be required.

You will no doubt find that most of the men using material do not appreciate the enormous expense involved in carrying more supplies than actually required, and while some of them



Efficiency.	Hours.	Rate.	Wages.	Bonus.	Total.
80%	129,470	$2.44	$31,499.69	$4,006.83	$35,506.52
100%	103,335	2.44	24,815.80	5,006.83	29,822.63
				Loss to Company	$5,683.89
100%	129,470	$2.44	$31,499.69	$6,318.13	$37,817.82
80%	129,470	2.44	31,499.69	4,006.83	35,506.52
				Loss to Men	$2,311.30

FIG. 7.—EFFICIENCY RECORD OF A SHOP.

are perfectly willing to return the excess stock, charged out, to the general storehouse from which it was drawn, many others are unwilling to part with it unless compelled to do so. While it is true that the men doing the actual work are naturally best qualified to determine what amount of material they should have, you will find a tendency to over-estimate, with the result that certain work will be overcharged, and if not properly controlled by some one department, the excess material in many cases is left lying around, depreciating in value, or is perhaps used for some other purpose without the proper charge being made.

Material drawn from stock and charged out, but not put in actual use, will not receive the same care and attention it would if it was carried as an asset under the direct charge of a supply agent or storekeeper. It will be found that on many railroads, where material is drawn from stock and charged out, the responsibility of the stores department ceases and it then comes under the care of a foreman or a road supervisor, who does not, in most cases, realize the necessity of properly accounting or caring for it, and the railroad becomes the loser. This division of responsibility is not conducive of good results and it has a tendency to increase the stock rather than keep it within reasonable limits, for the reason that the stores department in making up requisitions cannot take into consideration material charged out but not consumed.

If all material, whether in stock or charged out and not consumed, was placed under the direct charge of the supply agent and storekeeper, whose entire time and attention is given to this subject, the best results should be obtained. It is, of course, understood, that such officers should be well informed as to the use of material for various purposes, which can only be accomplished by personal and direct contact with the work under way and by interviewing those in charge of such work.

In this connection we must not overlook the question of responsibility over scrap. All scrap, with few exceptions, has, like new material, a market value and represents so much money invested. On some roads the stores department is held responsible until it is disposed of, while on others it is carried under the jurisdiction of a foreman. If the scrap pile is not gone over intelligently to recover good parts and the balance sorted according to its class and character, the railroad company cannot expect to get the full benefit of the credits they are entitled to.

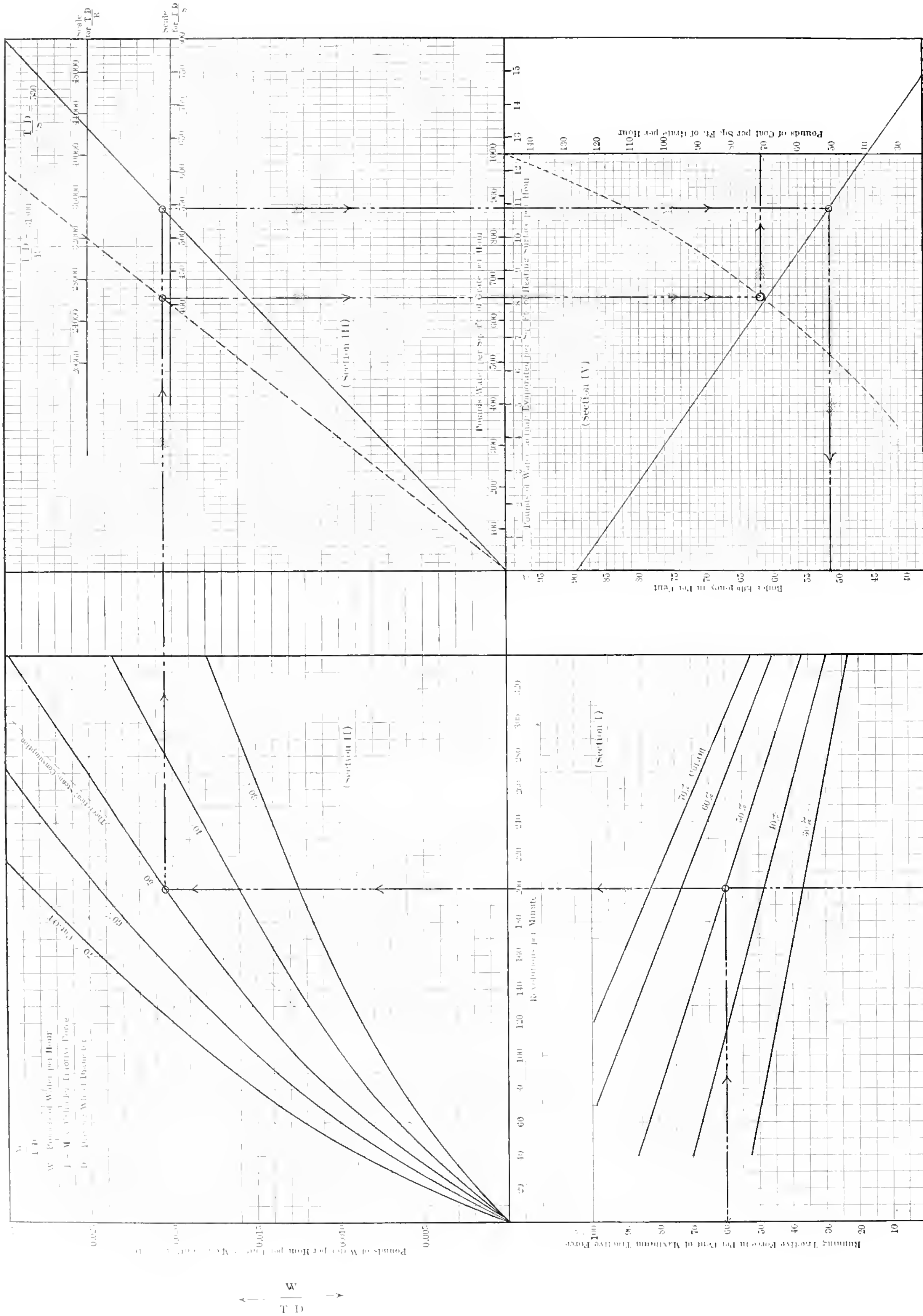
It is just as important to have a well regulated system of handling and caring for scrap, as for new material, and it will be found, where proper care and judgment are exercised in dealing with this class of material, that you can frequently pick out good material and avoid the purchase of new.

The constant increase in cost of material used by our railroads necessarily means the outlay of additional capital and this fact alone makes it all the more obligatory on our part to keep the amount of stock reduced to the minimum consistent with safety. To do this the stores department must control all material, new as well as scrap, charged out or not, and must be given full authority to handle it for the best interests of the service and by centering the responsibility it will enable the department to give a more accurate account of material on the system.

* Abstract of a paper read before the Railway Storekeepers' Association.
† Special Agent, Purchasing Department, Pennsylvania Railroad.

Freight Car Efficiency.—It can hardly be disputed that it is to the mutual advantage of the railroads of the country to strive continually to secure the highest possible efficiency from the equipment, regardless of the temporary condition of any individual road as regards car supply. The average per cent. of cars in shops for all roads reporting is 5.48 per cent. It will be noticed that the per cent. of the individual roads varies considerably, many of the larger roads being above the general average, and it is evident that there is room for improvement in the shop situation. It is customary on many roads to make reductions from time to time in shop expenses. This may not occur often when there is a local shortage, but it does occur frequently when there is a general shortage, and the effect of this policy on the general efficiency will be better appreciated when it is considered that a decrease of but .5 in the per cent. of cars in shop would be equivalent to an increase of 9,490 cars with an approximate value of $9,500,000. The benefit would not be confined to the general situation. It is certainly poor economy for the individual railroad to allow shop cars to accumulate which have a per diem value of 50 cents, merely to make a temporary reduction in maintenance of equipment expenses. Similarly, an increase in the loaded mileage of 1 per cent. would make available 18,980 additional cars. By raising the average loading but one ton per car, the available cars could be increased by 69,457. An increase of 1 mile per car per day means 70,305 more cars, the value of which at the average earnings for the country approximates $200,000 per day.—*Arthur Hale, Chairman, Committee on Car Efficiency, The American Railway Association.*

Brick Arch to Reduce Smoke.—A more conclusive test of the brick arch is desirable because the tests so far made show that gases and smoke given off by the coal are more thoroughly burned in fireboxes equipped with brick arches, and less black smoke given off.—*Report of Committee, Traveling Engineers' Association.*


(Section I)
(Section II)
(Section III)
(Section IV)
Revolutions per Minute
Boiler Efficiency in Per Cent
Pounds of Coal per Sq. Ft. of Grate per Hour
Running Tractive Force in Per Cent of Maximum Tractive Force
W
T D

A METHOD OF PLOTTING LOCOMOTIVE CHARACTERISTICS.

By Lawford H. Fry.

The diagram shows a system of plotting the results of locomotive tests to give a series of characteristic curves which cover the whole range of operation. It is divided into four sections. In the lower left hand corner, Section I, is a series of curves which give the relation between the cylinder tractive force, the cut-off and the speed. The curves in the upper left hand corner, Section II, show the relation between the hourly water consumption, the cut-off and the speed; the curves in the lower right hand corner, Section IV, show the hourly coal consumption and the boiler efficiency for any given conditions.

The four sections of the diagram are placed so that for any given combination of tractive force and speed the corresponding water and coal consumption may be determined readily.

The curves in the diagram are characteristic of a modern high speed balanced compound locomotive. They have been plotted from the Pennsylvania Railroad tests at St. Louis and are a combination of the results obtained with the New York Central Cole balanced compound and the Atchison, Topeka & Santa Fe Vauclain balanced compound. Both these are Atlantic type engines and on the testing plant gave very similar results.

In Section I the horizontal scale is revolutions per minute, while the vertical scale is indicated cylinder tractive force expressed in per cent. of the maximum tractive force given by formula. In this case, the locomotives being four-cylinder compounds, the maximum tractive force is given by the formula:

$$T = \frac{d^2_h \times s \times \frac{2}{3} P}{D} + \frac{d^2_e \times s \times \frac{1}{4} P}{D}$$

where

$T =$ the maximum tractive force in pounds.
$d_h =$ the diameter of the high pressure cylinder in inches.
$d_e =$ the diameter of the low pressure cylinder in inches.
$s =$ the stroke in inches.
$P =$ the boiler pressure in pounds per square inch.
$D =$ the driving wheel diameter in inches.

The diagonal lines show the cylinder tractive force at any speed for a given cut-off in the high pressure cylinder. For example, at 50 per cent. cut-off the tractive force falls from 80 per cent. of the maximum at 80 revolutions a minute to 40 per cent. of the maximum at 320 revolutions per minute. And, again, if a vertical line is drawn corresponding to 200 revolutions a minute it is found that at 30 per cent. cut-off the tractive force is about 37 per cent. of the maximum, at 50 per cent. cut-off the tractive force is about 60 per cent. of the maximum, and at 70 per cent. cut-off about 83 per cent. of the maximum tractive force. These figures apply only to the cylinders and do not indicate whether the boiler can supply sufficient steam to maintain the speeds at the cut-offs mentioned. The question of steam consumption and supply is determined by the remainder of the diagram.

The steam consumption is shown by the curves in Section II in the upper left hand corner of the diagram. Here the horizontal scale is revolutions per minute, as before, while the vertical scale measures the water consumption, and a curve is drawn for each cut-off to show the water consumption for the various speeds.

In order to make the curves generally applicable to locomotives of the type under consideration the water consumption is not given directly in pounds, but is referred to the factor T D, which depends on the cylinder volume and the boiler pressure. To get an idea of the absolute amount of water represented by these curves it may be assumed that the maximum tractive power (T) of the locomotive for which the curves are drawn is 22,000 pounds and the driving wheel diameter (D) 80 in., making the factor T D = 1,760,000. Therefore the figure for water consumption given by the curves, if multiplied by the factor 1,760,000, will give the total water consumption in pounds per hour. For example, with a cut-off of 50 per cent. at 200 revolutions per minute the water consumption will be 0.0205 × 1,760,000 = 36,080 pounds per hour. If another locomotive of the same type, but different dimensions, is considered the water consumption will vary in proportion to the changes in the maximum tractive force and the driving wheel diameter.

The diagonal lines in the upper right hand corner, Section III, enable one to change from the total hourly water consumption in Section II to the rate of evaporation per square foot of grate area or per square foot of heating surface. There are two horizontal scales, one the rate of evaporation per square foot of grate corresponding to the heavy diagonal marked $\frac{TD}{R}$, the other the rate of evaporation per square foot of heating surface corresponding to the light diagonal marked $\frac{TD}{S}$. As indicated by the broken lines it is only necessary to draw a horizontal line from the point of total water consumption, and then from the point of intersection with the diagonal to drop perpendiculars to the scales of evaporation. The position of these diagonals is determined for each particular locomotive by the respective relations of the grate area and the heating surface to the cylinder factor TD. The diagonals drawn in the diagram are for a locomotive in which the grate area is to the cylinder factor TD as 1 is to 31,800, or $\frac{TD}{R} = 31{,}800$, and the heating surface is to TD as a is to 530, or $\frac{TD}{S} = 530$, R being the grate area and S the heating surface in square feet. To enable the diagram to be applied to locomotives having other proportions of grate area and heating surface, the scales for $\frac{TD}{R}$ and $\frac{TD}{S}$ have been drawn. To get the diagonal for any given proportions it is only necessary to draw a line from the origin through the proper point on the scale.

In the lower right hand corner, Section IV, curves of coal consumption and boiler efficiency are plotted. The coal consumption curve has as its base the rate of evaporation per square foot of grate, while the boiler efficiency curve is based on the rate of evaporation per square foot of heating surface. By continuing down the perpendiculars from Section III to intersect the curves the rate of coal consumption and boiler efficiency which correspond to the given conditions are found.

From the foregoing it will have been seen that the four sections of the diagram cover the complete economy of the operation of a locomotive. The broken lines show the process of tracing out the values for a given combination of tractive power and speed. In the case chosen the locomotive is required to develop 60 per cent. of the maximum tractive force at 200 revolutions per minute. With the dimensions of the locomotive from which the curves are constructed this would be approximately an indicated tractive force of about 13,200 pounds at 47.5 miles an hour. From Section I it is seen that this combination requires a cut-off of 50 per cent. Carrying the perpendicular from this point up to the water line for 50 per cent. cut-off in Section II, it is seen that the water consumption is 0.0205 pounds per unit of cylinder factor (TD), or with the assumed dimensions 36,080 pounds an hour. Taking a horizontal line across to cut the diagonals in Section III and then dropping perpendiculars from the points of intersection, the exaporation per hour is found to be about 650 pounds of water per square foot of grate area and about 10.9 pounds per square foot of heating surface. By continuing the perpendiculars down to intersect the curves in Section IV it is found that the above conditions require about 71 pounds of coal to be fired per square foot of grate area per hour, while the boiler efficiency will be about 52.5 per cent. These curves of boiler efficiency and rate of firing are based on the St. Louis tests with a coal of high fixed carbon and would have to be changed for a different grade of coal.

Steam Consumption Curves.—It is interesting to compare the steam consumption curves in Section II with the line of theoretical steam consumption, assuming that the cylinders at the point of cut-off are completely filled with steam at the full boiler pressure. On this assumption the steam consumption

would be increased directly in proportion to the speed and would be represented by a straight line, as is shown by the dotted line for 50 per cent. cut-off. The actual and the theoretical lines cross each other at about 220 revolutions per minute, and the actual curve lies above for lower speeds and below at the higher speeds. A possible explanation for this is that at the lower speeds the cylinder condensation and the leakages past the piston cause more steam to be used than can be contained in the cylinder at the full pressure, while at the higher speeds the wire-drawing offsets the losses and the cylinder cannot take in its full supply of steam.

The Tractive Force Curves.—The tractive force curves in Section I show a decreasing tractive force with increasing speed. These curves are practically straight lines and apparently converge to a point on the line of zero tractive force at about 580 revolutions per minute. This with a stroke of 26 in. would give a mean piston speed of about 2,520 feet a minute. The drop in the tractive force with increasing speeds is due to the wire-drawing of the steam through the steam passages and the convergence of the lines indicates that at a piston speed of about 2,520 feet per minute, with any cut-off, the entire energy of the steam would be absorbed in overcoming friction and no tractive force would be produced. Of course such a speed is impracticable as the highest speed which can be attained is that at which the tractive force is just sufficient to overcome the friction of the machine. In the AMERICAN ENGINEER AND RAILROAD JOURNAL for November, 1906, page 441, was published an abstract of a paper by Prof. W. E. Dalby in which he plotted a similar series of tractive force curves from Prof. Goss' experiments.

Cylinder Factor.—The cylinder factor (TD), that is, maximum cylinder tractive force multiplied by the driving wheel diameter, was proposed by the author in the AMERICAN ENGINEER AND RAILROAD JOURNAL, October, 1902, page 315, as a useful factor in the comparison of locomotives and has since then found considerable use. It has, however, suffered under the disadvantages that it did not represent an actual physical quantity. Mr. H. A. F. Campbell has recently pointed out to the author that this disadvantage can be removed and the factor may be shown to have a concrete value.

It can be shown that the factor TD is proportional to the foot-pounds of work done in the cylinders at each revolution, and is therefore properly known as the cylinder-duty-factor. When the tractive force is T pounds and the driving wheel diameter is D inches the locomotive at each revolution of the driving wheels moves forward πD inches and does πTD inch-pounds or $\frac{\pi}{12}$ TD foot-pounds of work in the cylinders. That is, T D multiplied by $\frac{\pi}{12}$ or 0.262, gives the foot-pounds of work done in the cylinders at each revolution.

The factor TD divided by the heating surface $\frac{TD}{S}$ or BD, (B representing the tractive force T divided by the heating surface) has been used as a measure of the steaming capacity of a locomotive. Its value is perhaps increased if instead of considering it as an abstract conception it is realized that this steaming capacity factor, $\frac{TD}{S}$, is proportional to the foot-pounds of work done per square foot of heating surface in each revolution. To get the actual number of foot-pounds per square foot of heating surface the factor is to be multiplied as above by 0.262.

In giving a meaning to the vertical scale of steam consumption, $\frac{W}{TD}$, of the curves in Section II it is better not to think of TD as proportional to the foot-pounds per revolution, but to take into consideration the fact that TD is very closely proportional to the weight of a cylinder full of steam at the maximum cut-off. From this point of view the steam consumption is measured on a scale giving readings which are proportional to the number of maximum cylinderfuls of steam which are used per hour.

STATISTICS OF RAILWAYS IN THE UNITED STATES.

The 19th annual statistical report of the Interstate Commerce Commission for the year ending June 30, 1906, contains some very interesting figures in connection with the railways in the United States. The report shows that the total single track railway mileage in the U. S. was 224,363 miles, an increase of 6,262 miles during the year. The number of corporations for which mileage is included in the report was 2,313.

The number of locomotives in service on June 30, 1906, was 51,672, an increase of 3,315. The total number of cars of all classes was 1,958,912, an increase of 116,041 for the year. The average number of locomotives per thousand miles of line was 232 as against 223 for the previous year. The average number of cars per thousand miles of line was 8,810 as compared with 8,494 for the previous year. The number of passenger miles per passenger locomotive was 2,055,309, an increase of 6,751 miles for the year. The number of ton miles per freight locomotive was 7,232,563, an increase of 541,863 ton miles.

The number of persons on the pay-rolls of the railways in the United States was 1,521,355, which is equivalent to 684 employees per 100 miles of line, a total increase of 139,159 persons or 47 per 100 miles of line. Of the employees nearly 60,000 were enginemen, 62,678 were firemen, nearly 44,000 were conductors and over 119,000 were other trainmen. Disregarding a small number not assigned the employees were grouped into four general divisions as follows: For general administration 57,054, an increase of 2,943. For maintenance of way and structures 495,879, an increase of 47,509. For maintenance of equipment 315,952, an increase of nearly 35,000. For conducting transportation 649,820, an increase of over 54,000. The total amount of wages and salaries paid to employees during the year was $900,801,653. This amount, however, is deficient more than $27,000,000 because of the loss of railway records at San Francisco.

The par value of railway capital outstanding was $14,570,421,478, which is equivalent to a capitalization of $67,936 per mile. Of the total capital stock outstanding 33.46 per cent. paid no dividends; during the previous year 36.17 per cent. paid no dividends. The amount of dividends declared during the year was equal to 6.03 per cent. on dividend paying stock. Figures for the previous year were 5.78 per cent.

The number of passengers carried during the year was 799,507,838, being 60,673,171 more than in the previous year. The number of passengers carried one mile was 25,175,480,383, the increase being about 1⅓ billion. The ton mileage was 215,877,551,241, the increase being nearly 29½ billion ton miles.

The number of ton miles per mile of line was 982,401, indicating an increase in the density of freight traffic of 121,005 ton miles per mile of line for the year. The average revenue per passenger per mile was 2.002 c.; the average for the preceding year being 1.962c. The average revenue per ton mile for freight was .748c.; the figure for the preceding year being .766c. The ratio of operating expenses to earnings for the year was 66.08 per cent.; the figure for the preceding year being 66.78.

The gross earnings per mile of line averaged $10,460, an increase of $862. The operating expenses averaged $6,912, an increase of $503. The net earnings per mile of line were thus $3,548. The figures for 1905 and 1904 were $3,189 and $2,998 respectively.

The total number of casualties to persons on the railways was 108,324, of which 10,618 were killed. Of the number killed 2,310 were trainmen, 147 switch tenders, etc., and 1,472 were other employees. The number of passengers killed during the year was 359 and the number injured 10,764. During the previous year 537 passengers were killed and 10,457 injured. Of these 146 passengers were killed and 6,053 injured because of collisions and derailments. The total of persons other than employees and passengers killed was 6,330; injured 10,241. One passenger was killed for every 2,227,041 carried and one injured for every 74,276 carried. Similar figures for 1905 were 1,375,856 and 70,655. One passenger was killed for every 70,126,686 passenger miles and one was injured for every 2,338,859 passenger miles.

STEAM MOTOR CAR.

Intercolonial Railway.

The Intercolonial Railway of Canada is building three steam motor cars from designs drawn up in the office of the superintendent of motive power, one of which has recently been completed and put into service between St. John and Hampton, N. B.

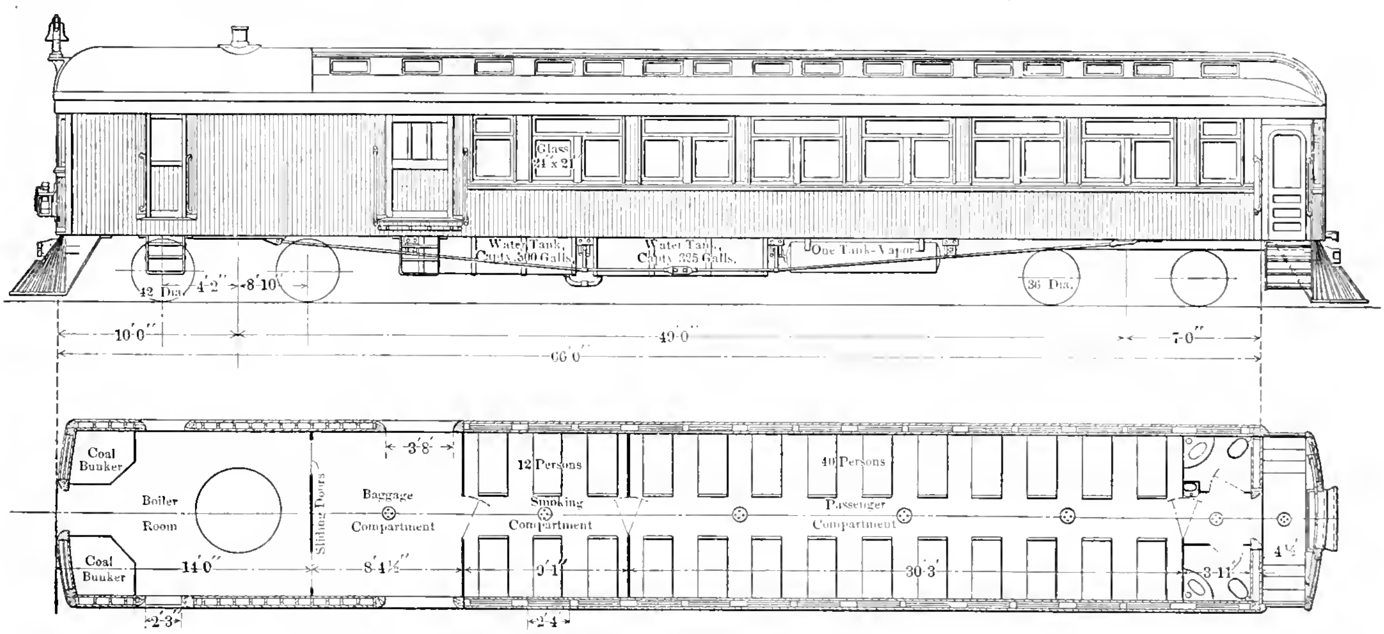
These cars are somewhat similar to other steam motor cars put into service in this country and consist of a small four-wheel locomotive carrying a vertical boiler, which forms one of the trucks of a passenger coach, the other truck being of the ordinary type. The cars in this case measure 66 ft. over end sills and weigh about 142,000 lbs. fully equipped and loaded. The locomotive is capable of developing about 200 h.p. and gives a tractive effort of 8,500 lbs. It is designed to give a speed of 25 miles per hour on a 1 per cent. grade. Coal is used for fuel, there being two bunkers giving a combined coal carrying capacity of one ton.

The car body in general follows the design and arrangement of the first-class coaches in use on that road. It is of wooden construction, having eight longitudinal sills, four of which are 4½ x 8 in., two being 5 x 8 in. and side sills 5 x 8¾ in. The superstructure is of the ordinary type for a heavy wooden passenger coach, with the exception of a short distance at the motor end where the roof is made of sheet iron and curved from plate to plate, being bolted in place. This is done to permit the roof to be easily removed when it is desired to take out the boiler. The cars are intended to run in either direction, with or without trailer, and are equipped with a pilot and M. C. B. coupler at both ends. They are also equipped with through piping and hose connections for both steam heat and air brakes.

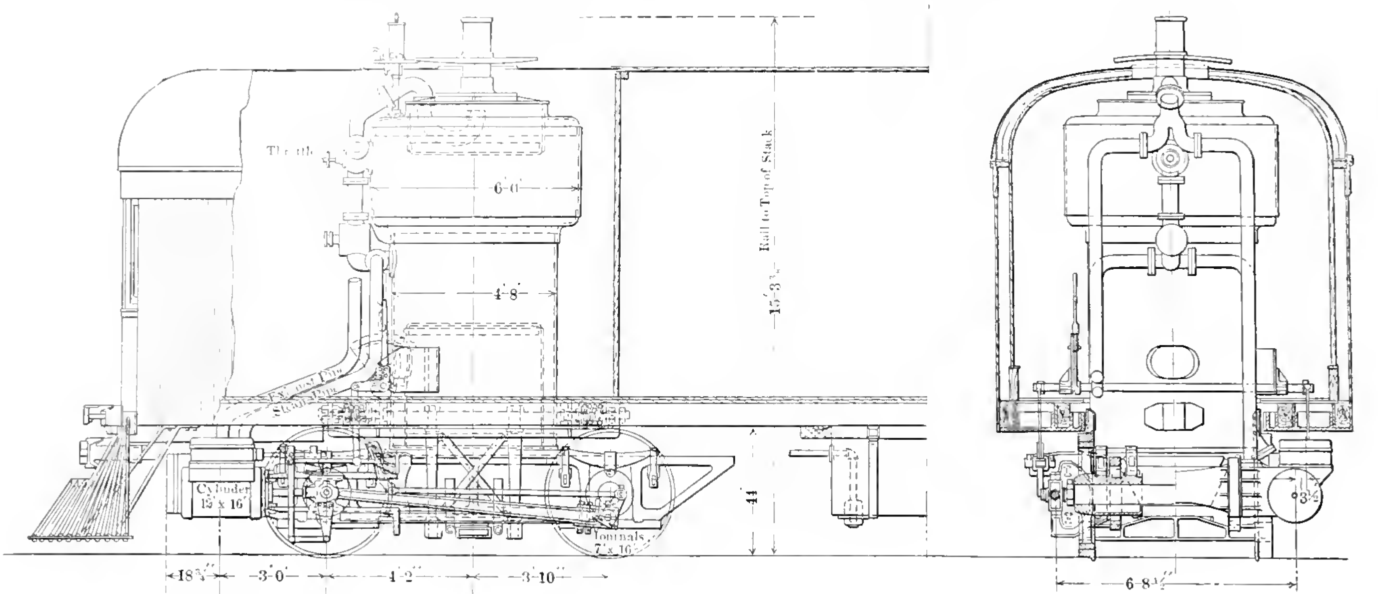
They are fitted with steel platforms at either end, the one at the motor end, however, being included in the boiler room and cab space. The boiler room is fitted with sliding side doors, which are set some distance back from the ends of the car. It measures 13 ft. 6 in. long inside and contains the boiler, its attachments and all operating gear, as well as a 9½ in. pump, coal bunker, etc. This adjoins a baggage compartment of 8 ft. 4½ in., which is fitted with two sliding side doors, there also being two doorways leading to the boiler room and a door to the smoking compartment, which immediately adjoins it. The smoking compartment has a seating capacity of twelve persons and is separated from the regular passenger compartment by a partition. The passenger compartment has a seating capacity of forty persons, and is fitted out in the same manner as a first-class day coach. The vestibule at the rear end of the car is somewhat longer than the ordinary standard, in order to give space for the controlling equipment at this end. An engineer's brake valve, a throttle closing device, whistle and bell cords, etc., are installed at this point, being arranged so as to give an unobstructed passage when the car is being operated from the opposite end.

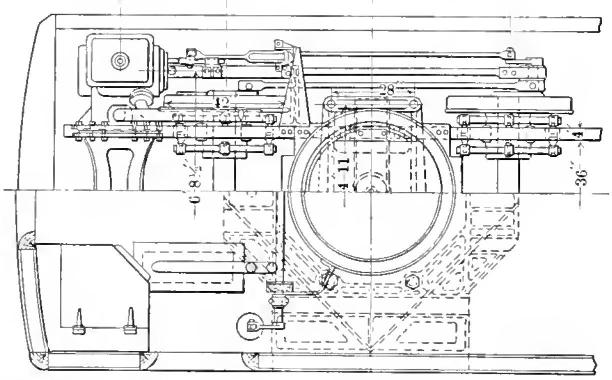
The cars are heated with steam and lighted by incandescent mantle lamps, using the new vapor system of the Safety Car Heating & Lighting Company.

STEAM MOTOR CAR, INTERCOLONIAL RAILWAY.



PLAN AND ELEVATION OF 66-FOOT STEAM MOTOR CAR, INTERCOLONIAL RAILWAY.





GENERAL ARRANGEMENT OF MOTOR TRUCK, STEAM MOTOR CAR.

The locomotive truck consists of wrought iron bar frames, 4 x 3 in. in section for the top rail, fitted with pedestals, shoes and wedges, binders, etc., in the usual manner, and having an extension on the forward end to which are bolted the 12 x 16 in. cylinders. A rigid steel casting is secured between the extensions of the frames to give stiffness. The drivers are 42 in. in diameter and have a wheel base of 8 ft. They are coupled together by a side rod and the main crank pin is on the rear driver. Balanced slide valves operated by Walschaert valve gear are used. The drivers are not equalized, each supporting a separate pair of semi-elliptic springs, there being one on either side of the locomotive frame over each journal box. All driving journals are 7 x 16 in.

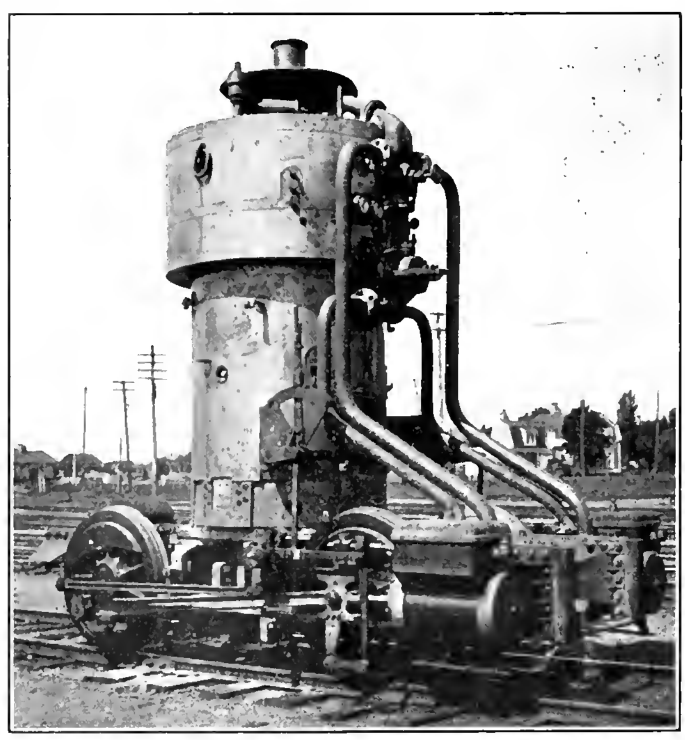
The boiler, a section of which is shown in one of the illustrations, is of the vertical type, and carries a pressure of 180 lbs. per square inch. It contains 361 1½-in. copper tubes, giving a heating surface of 684.7 sq. ft. The firebox has a heating surface of about 44 sq. ft., giving a total heating surface for the boiler of 728.7 sq. ft. The grate area is 11.5 sq. ft. Steam is taken from the top of the steam drum and is somewhat superheated by the 6 in. length of tubes, which project above the water level. The boiler is carried on top of the frames by a heavy steel casting fitted and bolted to both the frames and bottom of the boiler. The exhaust steam from the cylinders is carried to the stack. The piping connections and arrangement, as well as the general design of the locomotive truck, is shown in one of the illustrations.

The method of supporting the car body upon the motor truck has been solved in a very satisfactory manner. Since the boiler must project up through the car body and must necessarily be rigid with the motor truck and since, further, the motor truck must be capable of free movement in relation to the car body, it was necessary to design a special form of support. This has been done by the use of a large cast steel body bolster, which weighs about 4,430 lbs., and has a large opening in the center through which the boiler passes. This casting is securely fastened to the underframe of the car body and carries four heavy steel struts which connect to another cast steel bolster passing across below the ash pan of the boiler.

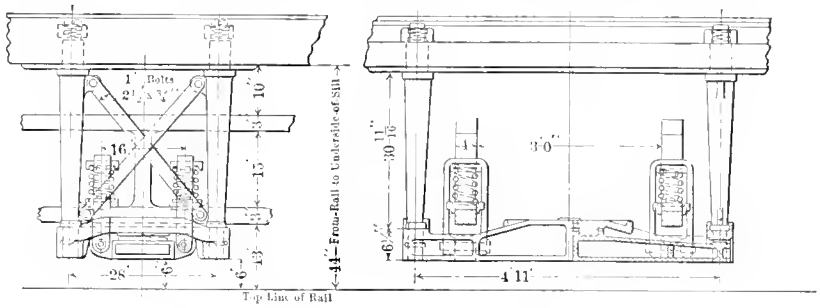
This bolster takes a bearing through a center plate on another steel casting, or truck bolster, which is hung from the engine frame by means of four wrought iron hangers fitted with equalizing springs. These springs rest in cup-shaped caps and seats, and allow the car body to take the different relative positions necessary when rounding curves. Buffing springs are arranged between the body bolster and the boiler to prevent any jarring when the car is in motion. This construction is clearly shown in the illustrations.

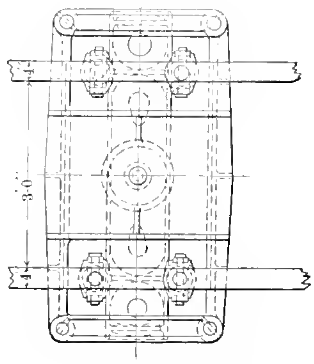
The water supply is carried in tanks suspended from the underframe, which have a combined capacity of 1,000 Imperial gallons. The boiler is fed by two Hancock inspirators.

The general dimensions of the car and its motor are shown in the following table:



MOTOR TRUCK AND BOILER, INTERCOLONIAL MOTOR CAR.





DETAIL OF SUPPORT ON MOTOR TRUCK.

CAR BODY.

Seating capacity	52 persons
Gauge of track	4' 8½"
Length over end sills	66' 0"
Width over side sills	9' 10"
Height, top of sills to under side of plate	6' 7¼"
Length, inside sheathing	65' 1⅛"
Width, inside sheathing	8' 11⅜"
Width, between deck rails	4' 10"
Height, inside, top of floor to under side of lower deck rail	7' 7¾"

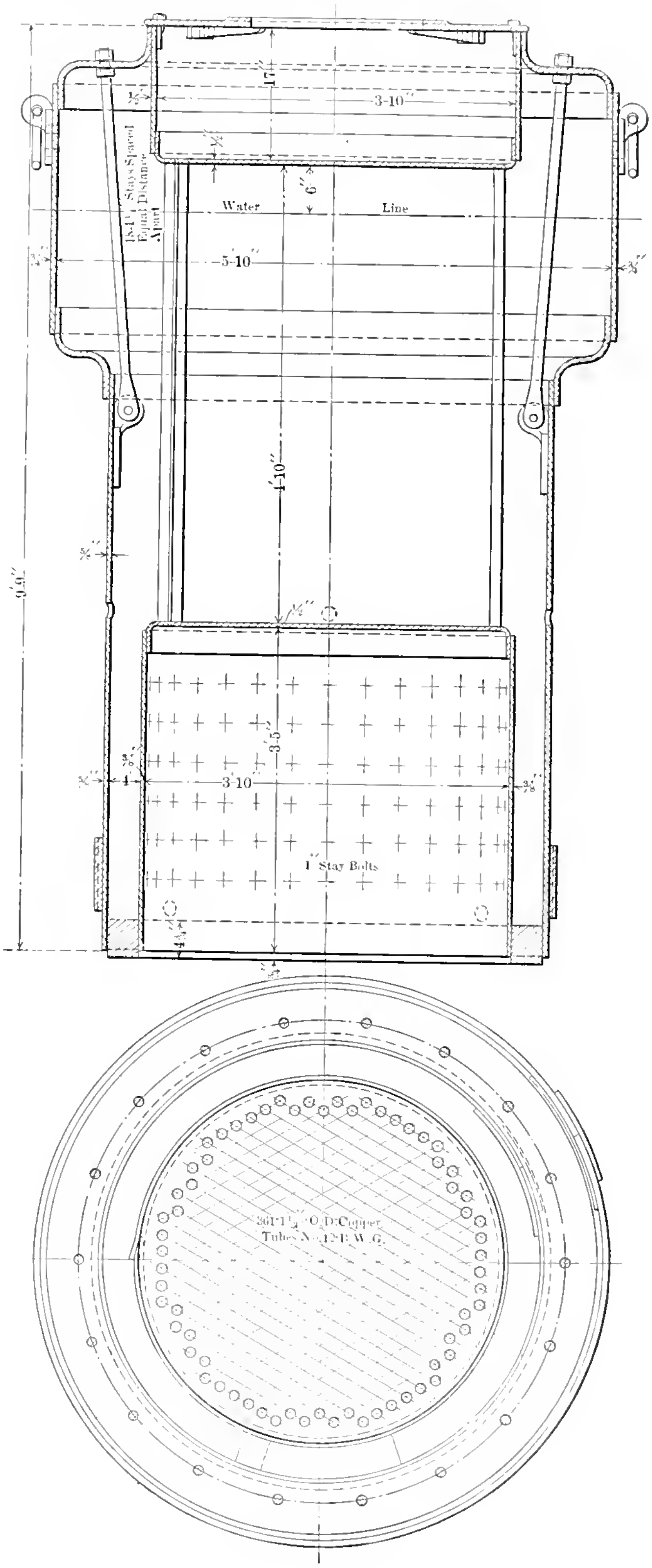
MOTOR TRUCK.

Cylinders	12" x 16"
Gauge	4' 8½"
Driving wheels	42" diam.
Wheel base of engine	8' 0"
Heating surface in tubes	684.672 sq. ft.
Heating surface in firebox	44.04 sq. ft.
Total	728.712 sq. ft.
Grate area	11.54 sq. ft.
Working pressure	180 lbs. per sq. in.
Test	250 lbs. per sq. in.
Weight of motor (without car)	51,000 lbs.
Total weight of motor and car loaded	142,000 lbs.
Tractive effort	8,500 lbs.
Horse power of engine, about	200
Speed on 1% grade	25 miles
Motor to haul a trailer of	40 tons

Train Lighting in Germany.—For some time past the authorities of the German State Railways have been experimenting with the incandescent gas light for illuminating their railway carriages, and the compartments of the "Stadtbahn" have been equipped with burners of the inverted type. The mantles, which, in railway traffic are continually subjected to shocks and vibration, have nevertheless proved to be quite durable, so that they can be used for several months. The cost of the incandescent mantles average about 5d. It has been found that pure oil gas is cheaper and gives better results than the mixture of three parts oil gas and one part acetylene, which was introduced several years ago. The experiments have proved that the inverted incandescent gas light is far cheaper, and gives at the same time a much better light than the flame system hitherto employed. The authorities of the German State Railways have therefore decided to introduce the inverted incandescent gas light throughout the whole railway system. This great change, which can, of course, only be carried out gradually, is expected to take two years.—*The Engineer (London).*

Number of Mallet Compound Locomotives in the U. S.—There are at present 50 Mallet articulated compound locomotives in service in this country, of which one is on the Baltimore & Ohio Railroad in pushing service; five are on the Great Northern Railway in pushing service; sixteen on the Northern Pacific in pushing service; twenty-five on the Great Northern Railway in road service and three are in pushing service on the Erie Railroad. All but one of these locomotives have been built during the past two years and most of them during the past year.

Railroad School for Telegraphy.—The Pennsylvania Railroad has organized a school of telegraphy at Bedford, Pa., where it will train men for this branch of its service. The men will not only be trained in telegraphy, but will also be instructed in the general duties of station agents. The time required to complete the course will be from six to eight months and a tuition fee of $2.00 per month will be charged. Immediately upon graduation the men are provided with salaried positions in direct line of promotion.



SECTION OF BOILER, INTERCOLONIAL STEAM MOTOR CAR

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

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Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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The variable speed motor may be used to splendid advantage in connection with many of the machine tools in railroad repair shops and its usefulness in that field will undoubtedly be still further extended. It is quite noticeable, however, that a number of lines of machine tools have been equipped with mechanical speed changing devices during the past year or two, which furnish about all the speed changes that can be used to advantage, and are giving successful service when used in connection with constant speed motor or belt drives.

The method of plotting a combination diagram, consisting of a series of curves which cover the whole range of operation of a locomotive, as described by Mr. Lawford H. Fry on another page, is of special interest. Such a diagram can be drawn for any particular size of locomotive to show the coal and water consumption directly in pounds per hour, the tractive force in pounds and the speed in miles per hour. With the aid of a chart of this kind the operating officer can see at a glance the effect which any change in speed or loading will have on the economy of operation.

A paper presented at the last meeting of the New York Railroad Club on "The Steam versus the Electric Locomotive" by Mr. Max Toltz, discusses the improvement possible in the operation of the present American steam locomotive. It is somewhat in the nature of a reply to the paper presented before the American Institute of Electrical Engineers last January, which gave detail figures to prove that a saving of $250,000,000 could be made in the cost of operation of our railways by substituting electricity for steam as a motive power. It shows that approximately an equal saving could be made with a much less capital charge by the application of three devices to the present steam locomotives. These are the superheater, feed water heater and automatic stoker. The first two are credited with a capacity for saving 20 per cent. each, and the stoker with 5 per cent., or an aggregate of 39.2 per cent. for the three. This saving in fuel, it is claimed, will be accompanied by a 30 per cent. reduction in the number of engine and roundhouse men and a 30 per cent. saving in the cost of water supply.

The following extract, concerning an editorial in our September issue entitled "The Successful Motive Power Department Official," is taken from a communication received from one who has been eminently successful in charge of a motive power department

"The essence of the whole thing is to provide definite measures with which to compare every man and every detail of business, in so far as it is possible to do so. The measuring stick from the standpoint of the manager must be definite and accurate. The measuring stick from the standpoint of the employe who is being measured, should impress him as being absolutely fair and that to whatever extent he is compared with the standard, his relative efficiency is due entirely to his own good or bad performance. The above may seem so self-evident that it is not worth while to emphasize them, but my experience has been that most people who are trying to accomplish results are liable to lose sight of the essential principles and unless they keep them before them constantly, their results are quite likely to be disappointing."

The article in this issue concerning the New York Central Lines apprentice system is the most important one of the series, as it presents a detail study of the purely educational part of the work. One reason why so many apprentice systems have failed is that this feature has not been arranged to meet the needs of the apprentice in a practical way. The New York Central Lines method is eminently practical and while it is only in the process of being developed, the results which have been gained during the past year or more, in which it has been in operation, are very satisfactory. With this in mind we have thought it necessary to go into the drawing and problem courses in considerable detail, in spite of the fact that other important articles have had to be held over until our next issue, in order to make room for it.

*   *   *   *   *   *   *

The apprentice instructors of the New York Central Lines

held their first annual conference at the Collinwood shops on September 18 and 19. An idea of the extent and importance of this meeting may be gained from the fact that over forty topics were considered, all of practical importance. We expect to present an abstract of the proceedings of this conference in our November issue, thus completing and rounding out the description we have been presenting of the apprentice system.

* * * * * * *

The Santa Fe is establishing an apprentice system, on a large scale, somewhat similar to that on the New York Central Lines. Mr. F. W. Thomas, formerly engineer of tests, has been placed in charge, with the title of supervisor of apprentices. The first school has already been started at the Topeka shops. Mr. C. M. Davis, formerly drawing instructor of the apprentice school at the Brightwood shops of the Big Four, has been secured to assist in this work. It will be recalled that Mr. Harrington Emerson in discussing the apprentice question at the recent meeting of the Master Mechanics' Association presented some interesting figures concerning the efficiency of the apprentices in the Topeka shops. It will be interesting to check this with comparative figures after the new system has become well established. Those who are familiar with the interest which Mr. John Purcell, the shop superintendent at Topeka, has always taken in the apprentices in his organization will realize that his hearty co-operation will be given in developing and perfecting this work at Topeka. As soon as it has been well started at that point it will be extended to the other shops on the system and thus, although they will, of course, not have any connection with the New York Central system, a line of practical apprentice schools will extend across the continent. Several other large railroads have the question of establishing similar apprentice systems under consideration.

We are fortunate in being able to present, in this issue, an article on "Shop Efficiency," by Mr. H. W. Jacobs. It goes somewhat more into detal as to the method of determining the exact efficiency of the individual worker, gangs, or shops as a whole, than was possible in the paper presented at the recent meeting of the Master Mechanics' Association by Mr. A. Lovell on "Shop Cost Systems" (July issue, page 274), or in the article in our June issue, page 221, by Mr. Harrington Emerson on "The Methods of Exact Measurement Applied to Individual and Shop Efficiency at the Topeka Shops," or in the article by Mr. J. F. Whiteford in our June issue, page 216, on "Roundhouse Betterment Work." This matter of calculating the exact efficiency of the individual or shop was one of the later developments (and one of the most important) of the betterment work. To set a standard time for a piece of work, or to determine a reasonable cost for a certain operation or the maintenance of a piece of equipment, and then to encourage the men to strive to reach it, is the key to the best work which has been done along betterment lines in our mechanical departments.

* * * * * * *

An important feature of the betterment work on the Santa Fe is that just as soon as possible the betterment department was merged into the regular mechanical department organization. At the present time four men, each having general supervision of the betterment work on a division, report directly to the assistant superintendent of motive power, Mr. H. W. Jacobs. These men are Mr. J. L. Sydnor, on the Coast Lines; Mr. C. J. Drury, on the Western Grand Division; Mr. E. E. Arison, on the Eastern Grand Division, and Mr. J. E. Epler, on the Gulf Lines. In addition to these Mr. Raffe Emerson assists Mr. Jacobs and Mr. J. F. Whiteford has general supervision of roundhouse work over the entire system. Bonus supervisors are located at each point. Mr. Clive Hastings handles statistical matters in connection with the betterment work and reports directly to the 2nd Vice-president, Mr. J. W. Kendrick.

* * * * * * *

We have had so many requests for the special article on betterment work on the Santa Fe, published in our December, 1906, issue, and for other articles which have since appeared concerning the later developments, that it has been suggested that a list of all the articles touching on this work, which have appeared in our journal, be published. These are as follows:

"Shop Betterment and the Individual Effort Method of Profit Sharing," by Harrington Emerson. (A reprint of a pamphlet which was prepared for distribution among the workmen on the Santa Fe.)—Feb., '06, page 61.

"Locomotive Repair Schedules," by C. J. Morrison. (A detailed description of the schedules in use at the Topeka shops.)—Sept., '06, page 338.

"The Surcharge Problem," by C. J. Morrison. (A description of the method of determining surcharges and how they are applied.)—Oct., '06, page 376.

The above article excited considerable discussion and communications concerning it were published on page 438 of the Nov., '06, issue, and 478 of the Dec., '06, issue, Mr. Morrison going into greater detail as to the exact methods of determining the surcharge on page 479. Other communications appeared on page 64 of the Feb., '07, issue.

"Betterment Work on the Santa Fe.' (A complete study of the development of this work and the general and specific results which had been obtained to date. The article covered 26 pages.)—Dec., '06, page 451.

Communications concerning the above article appeared in the Feb., '07, issue, page 63, and March, '07, page 102.

"Dispatching Board for Engine Repairs," by C. J. Morrison.—Apr., '07, page 131.

"Roundhouse Betterment Work," by J. E. Whitford.—June, '07, page 216.

"The Methods of Exact Measurement Applied to Individual and Shop Efficiencies at the Topeka Shops," by Harrington Emerson.—June, '07, page 221.

Communications concerning the above article appeared on pages 287 of the July, '07, issue, and 308 of the August issue.

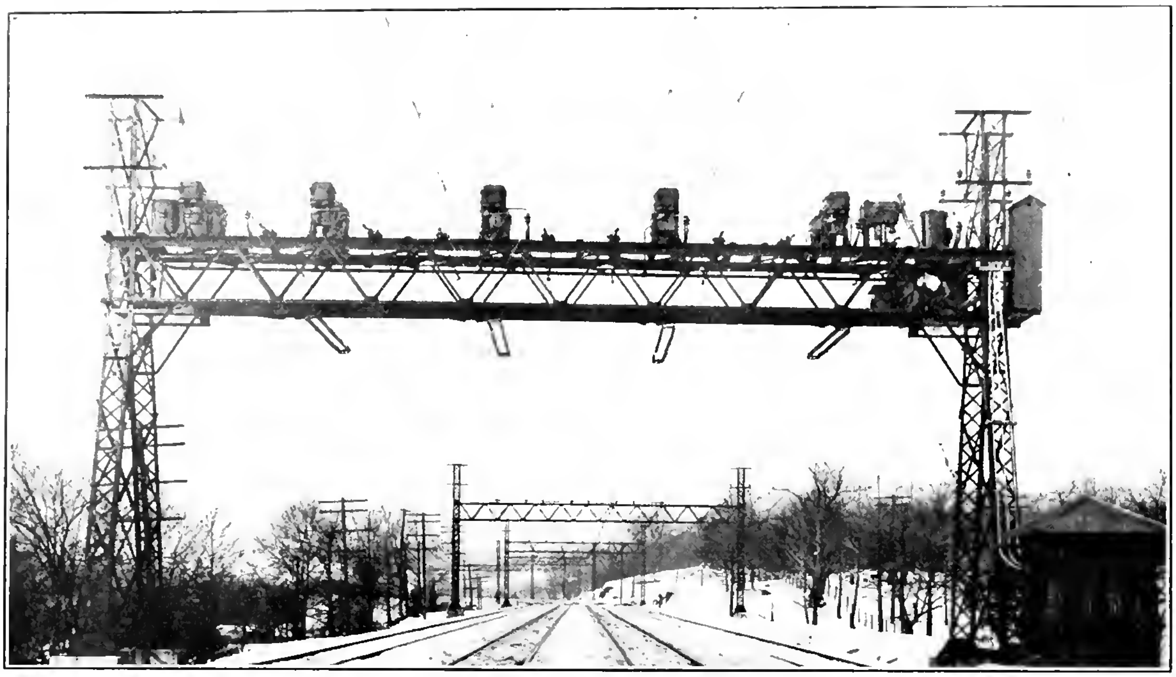
"Shop Cost Systems and the Effect of Shop Schedules Upon Output and Cost of Locomotive Repairs," by A. Lovell. (A reprint of a paper presented before the Master Mechanics' Association and an abstract of the discussion.—July, '07, page 274.

"Shop Efficiency," by H. W. Jacobs.—In this issue.

Editorial comments on the betterment work on the Santa Fe appeared on page 478 of the Dec., '06, issue; page 20 of the Jan., '07, issue, and page 231 of the June, '07, issue.

Occasionally we meet readers who in the course of conversation may remark that in a previous issue they noticed certain articles, or statements, with which they could not agree. When asked why they did not write a letter drawing our attention to it, they usually reply that they did not want to be drawn into a controversy, or did not care to criticise the work of the author. This is an entirely wrong attitude. We don't expect our readers to "swallow everything whole" that appears in this journal. Our aim is, as it has been in the past, to do our utmost to assist in upbuilding the motive power department and placing it on the high plane which its importance deserves. We try to bring out the best practices in vogue and to keep our readers informed as to all of the important developments which take place affecting that department. It is true, however, that what may prove best under one set of conditions may be entirely inadequate for others. Our desire is not so much to present material which can be applied directly by our readers as to set them thinking so that they can not only make intelligent use of what the other fellow is doing, but improve upon it if possible.

We use every precaution to have our facts and statements exact and clearly stated and if they don't agree with your beliefs or experiences we shall be only too glad to have you write and give us your views. There is nothing of greater assistance, or inspiration to an editor, than frank criticism, whether adverse or favorable. In the last three issues we presented two contributed articles containing some rather radical statements which the authors expected to have severely criticised. As a matter of fact the articles were published with the idea of stirring our readers up to make them think along certain important lines. It is true that they were criticised, but not as much as we would have liked to have had them. We want you to tell us frankly when you notice statements which you think are wrong, or with which you cannot agree; it will assist us greatly. We never publish communications without first asking the permission of the writer, and some which have helped us most have not been published at all. When for any good reason it is not thought advisable to use the writer's name the communication may appear over an assumed name, but the editors of course must know the writer's real name. Remember that this paper is published to meet your needs and that its success will be proportional to the degree in which it accomplishes this.



VIEW SHOWING ANCHOR BRIDGE AND OVERHEAD CONSTRUCTION—NEW YORK, NEW HAVEN & HARTFORD RY.

HEAVY ELECTRIC TRACTION ON THE NEW YORK, NEW HAVEN & HARTFORD RAILWAY.

On page 362 of the September issue of this journal will be found an article by Mr. E. H. McHenry, vice-president of the New York, New Haven & Hartford Railway, setting forth the causes leading up to the electrification of that system from Woodlawn, N. Y., where it joins the New York & Harlem Railroad, to Stamford, Conn., a distance of 21 miles. In the same article were given the reasons for adopting the alternating current system for power and some comments on the broad commercial aspect of electric traction for steam railways.

The present article will briefly describe some of the most interesting features of the novel overhead structure for conveying the power to the trains and the electric locomotives which are in use on the electrified section, and will be followed by an article describing the equipment of the Cos Cobb power house, where all of the current for the present installation is generated.

One of the chief advantages of the use of alternating current is that a high voltage may be used in the supply system. This necessarily compels great care in the matter of insulation and demands that the supply current be furnished from an overhead conductor instead of the third rail. Such an overhead system must necessarily be of the most substantial construction in every part. In the present instance a potential of 11,000 volts is furnished by the overhead conductor, which is supported over the center of the track by the so-called double catenary system. This system consists of two steel cables of specially high strength supported at intervals by steel bridge structures, and a copper conductor suspended from these two cables by means of hangers placed at frequent intervals. Wherever the cables pass over the steel supporting bridges they rest on massive porcelain insulators and at frequent intervals heavy bridges are provided against which the cables are anchored by means of specially constructed strain insulators.

The steel supporting bridges are of varying lengths, so as to accommodate from four to twelve tracks, as conditions may require, without the necessity of placing posts between the tracks. The bridges are of uniform design and consist of angle iron lattice bar construction. The intermediate bridges are of lighter construction than the anchor bridges, which are used at intervals of about two miles. The former have side posts of square cross section and comparatively light structure; while the anchor bridges have A-shaped posts and are made much heavier, to withstand the strain of the cables.

The anchor bridges are provided with automatic circuit breakers, by means of which the different sections of line may be isolated. They also carry lightning arresters and shunt transformers, for operating the circuit breakers.

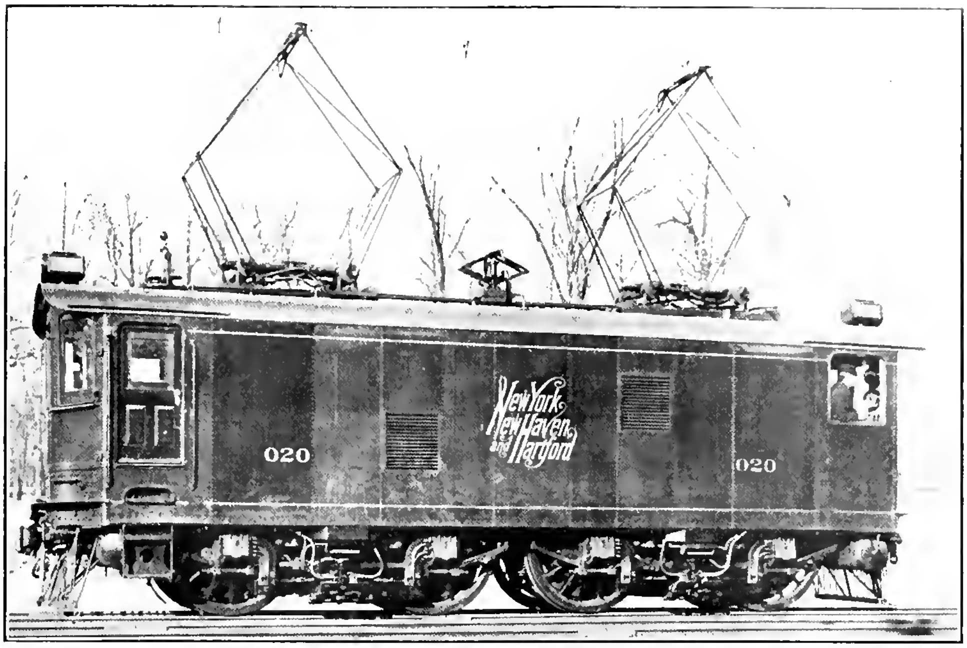
The main conductors over the running tracks are paralleled throughout their entire length by two feeder wires. These feeders constitute auxiliaries to the main track conductors and are connected to them at each anchor bridge through circuit breakers, thus providing the means for feeding around any particular section in case it is desirable to cut it out of service. There are also two other feeder wires, called power feeders, carried throughout the length of the line. These are connected to the third phase of the generating system and are used for operating the three phase apparatus at certain points on the road. Provision is also made on the bridges for carrying two other three phase circuits.

In laying out the bridges it was found that the sharpest curvature on the line was 3 degs. and this curvature will permit the stringing of the trolley wire in straight lines between points of support 150 ft. apart without deviating from the center of the track more than 8½ in. on each side. It was thus decided to place the bridges a fixed distance of 300 ft. apart and on the sharper curves to provide intermediate single poles from which pull over wires are carried to the catenary spans.

Intermediate Bridges.—The supporting posts of the intermediate bridges are approximately 38 ft. long by 1 ft. 10 in. square. Each is composed of 4 x 4 x 7/16 in. angles secured together by 2¼ x ⅜ in. lacing bars. They rest on foundations of concrete, each being secured by anchor bolts extending through the foundations. The cross truss is attached to the vertical posts by bolts and allows a clearance of 23 ft. 4 in. from the lower side of the truss to the top of the rails. The truss is 4 ft. 6 in. deep and 1 ft. 10 in. wide, the upper chord angles being 3½ x 6 x ⅜ in. and the lower 4 x 3½ x 5/16 in.

In the calculations of these bridges, very heavy weather conditions were assumed and provision was made for clamping the catenary cables on the intermediate bridges, so that they would be able to assist somewhat in withstanding the longitudinal pull. It was assumed that the entire system of bridges and cables might become coated with sleet and that this coating might be ½ in. in thickness around all surfaces. Under these conditions it was further assumed that the wind pressure on the bridges and catenary spans might be as high as 25 lbs. per sq. ft. The truss is also made strong enough, to prevent its buckling under the strain produced by the breakage of any pair of cables.

Anchor Bridges.—One of the illustrations shows an anchor bridge in the foreground and an intermediate bridge in the back-



SINGLE-PHASE LOCOMOTIVE—NEW YORK, NEW HAVEN & HARTFORD RAILWAY.

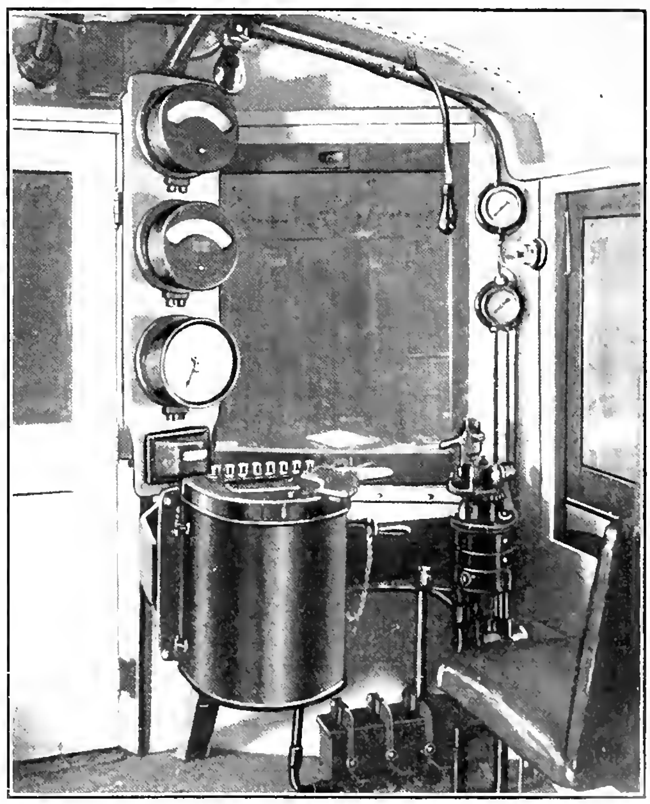
ground. The former are placed about two miles apart and consist of two A-shaped posts having a spread of 15 ft. at the base and a width of about 2 ft. The main members of the post consist of 6 x 4 x 5/8 in. angles. The truss across the tracks allows a clearance of 24 ft. 3 in. and is 4 ft. 6 in deep and 5 ft. wide, the upper chords consisting of 8 x 8 x 9/16 in. angles and the lower chords 4 x 3½ x 9/16 in. angles. Each anchor bridge has a ladder on one of the posts leading to a small platform at the end of the truss. This platform is provided with a hand rail and carries upon it a box containing a 11,000 volt low equivalent lightning arrester. A platform is built along the lower chord of the truss from which access to the block signals (not shown in the illustration) is provided by short ladders and also by other ladders to a platform upon the upper chord. This upper platform is surrounded by a hand rail to which are attached the supporting frames of the circuit breakers. The arrangement and connections are such that an attendant cannot in any way come in contact with live parts of the circuit.

Catenary Cables.—Each of the two catenary cables which support the copper conductor consists of an extra high strength steel cable 9/16 in. in diameter and made up of several heavy strands. The steel in each strand has an ultimate strength of 200,000 lbs. per sq. in. and each strand is heavily galvanized The complete cable has a strength of 33,800 lbs. The cables are strung between the bridges with a sag of 6 ft. at mean temperature and are dead ended and anchored at each anchor bridge through specially constructed insulators designed to stand an electric test of 50,000 volts and a working load of 20,000 lbs.

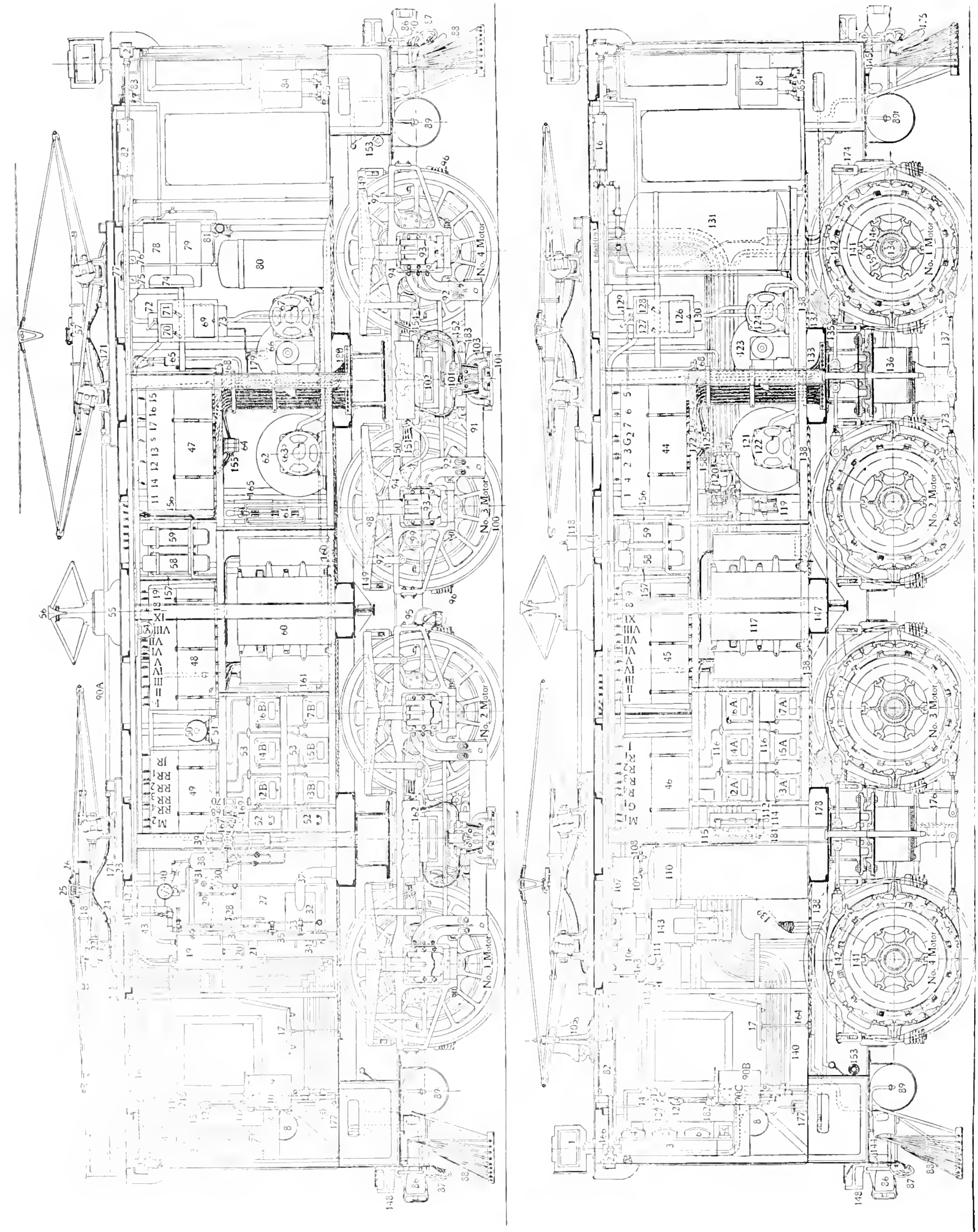
The conductor wire or trolley is supported from the catenary cables by means of triangular hangers of varying lengths, spaced 10 ft. apart. These hangers are so adjusted in length that the trolley wire is maintained in a horizontal position, being 6 in below the cables at the middle point of the span. The hangers consist of a pair of drop forged steel jams which engage the groove of the wire and are clamped by means of a malleable iron Y, screwed down upon the threaded portions of the jams. The sides of the triangle are then screwed into the Y and are bolted into the catenary cables above. A spacing piece the same length as the hangers completes the triangle.

At each anchor bridge it is necessary to provide an insulator in the trolley wire. This insulator is the piece of apparatus shown beneath the bridge in the illustration and consists of two bronze end castings to which the ends of the wire are bolted Two parallel sections of impregnated hard wood are fastened to these castings and to the lower sides of these wooden strips are secured renewable pieces of copper wire, the wire on each piece extending somewhat beyond the center, and thus permitting the sliding contact of the locomotive to pass from one section to the next without opening the circuit

Circuit Breakers.—The type of circuit breakers which has been developed for this installation consists of a cast iron framework adapted for bolting to the railing of the anchor bridges, which carries an iron box provided with a hinged cover. This cover is arranged to fit tightly and be entirely weatherproof. The moving parts of the circuit breaker are contained within this box and are made especially strong and reliable in their operation. Arrangements are provided so that when the cover of the box is opened the breaker will be automatically tripped and prevent any possibility of an attendant taking hold of live parts. A tripping coil is provided and also closing magnets, both of which are operated from a circuit supplied from the shunt transformers on the anchor bridge. This circuit is carried in an iron conduit to the adjoining signal tower where a switchboard is provided and fitted with switches so that any circuit breaker may be tripped or closed by the attendant in the signal tower. The breaker is also arranged to open automatically on an overload. The auxiliary feeder wires are looped into the bus bars on each alternate anchor bridge. These connections are made through automatic circuit breakers, so that in case of the grounding of the bus bar structure of any bridge one of the auxiliary feeders will pass around the grounded bridge to the next section beyond. On each anchor bridge one auxiliary feeder is broken by a strain insulator and connections are made through a circuit breaker to the bus bar. The other feeder is carried directly through and a single tap connection is made from the



INTERIOR OF CAB AT MOTORMAN'S STATION—NEW HAVEN ELECTRIC LOCOMOTIVE.



SECTIONS SHOWING ARRANGEMENT OF APPARATUS ON BOTH SIDES OF NEW HAVEN ELECTRIC LOCOMOTIVE.

1. Headlight.
2. Train Line Receptacles, Type 444 D-E and F.
3. Instrument Board.
4. Speed Indicator Meter.
5. D. C. Ammeter Motors.
6. A. C. Ammeter Motors.
7. Temperature Indicator Meter.
8. Equalizing Reservoir Air Brake.
9. No. 1 Master Controller.
10. No. 1 Automatic Motorman's Brake Valve.
11. No. 1 Independent Brake Valve.
12. Duplex Gage Main Res. and Train Line.
13. Whistle Handle.
14. Straight Air-Brake Gage.
15. Three-Way Snap Switch in Light Circuit.
16. No. 1 Junction Box.
17. Motorman's Seat.
18. No. 1 A. C. Pantograph Trolley.
19. No. 2 Oil Circuit-Breaker.
20. Overload Trip.
21. Oil Tank on Circuit Breaker.
22. Insulators for Pantograph Trolley.
23. Support for A. C. Trolley.
24. High-Tension Cable from A. C. Trolleys.
25. A. C. Trolley Shoe.
26. A. C. Trolley Lock Cylinder.
27. Steam-Heating Boiler.
28. Gage—Air Pressure on Burner.
29. Water Gage.
30. Drain Cup.
31. Try Cocks.
32. Fire Door.
33. Burner.
34. Gold Car Co. Regulating Valve.
35. Mason Regulating Valve.
36. Steam Line from Boiler.
37. Air Inlet to Fire-Box.
38. Water Feed Regulator.
39. Hand Brake Wheel.
40. Steam Gage.
41. Safety Valve.
42. Stack for Boiler.
43. H. T. Conduit from Oil Switch to Transformer.
44. Switch Group No. 1.
45. Switch Group No. 2.
46. Switch Group No. 3.
47. Switch Group No. 4.
48. Switch Group No. 5.
49. Switch Group No. 6.
50. Motor Generator Set for Battery Charging.
51. Base for Motor Generator Set.
52. Storage Battery.
53. No. 2 Set of Resistance Grids.
54. A. C. Integrating Wattmeter.
55. Base for D. C. Trolley.
56. D. C. Trolley.
57. No. a A. C. Pantograph Trolley.
58. Preventive Coil, 100 Volts, 250 Amps.
59. Preventive Coil, 50 Volts, 500 Amps.
60. No. 2 Transformer.
61. Main D. C. Switch.
62. No. 2 Blower Motor Fan Casing.
63. No. 2 Blower Motor.
64. Permanent D. C. Field Shunting Grid No. 2.
65. Hand Air Pump for Unlocking A. C. Trolley.
66. No. 2 Air Compressor.
67. No. 2 Air Compressor Motor.
68. Magnet Valves.
69. No. 2 Fuse Box.
70. Canopy Switch for No. 2 Blower Motor.
71. Canopy Switch for No. 2 Compressor Motor.
72. No. 2 Motor Control Cut-out.
73. No. 2 A. C., D. C. Change-Over Switch.
74. Relay Box.
75. Snap Switch for Cab Lights.
76. Snap Switch for Headlights.
77. S. P., D. T. Switch Light Circuit.
78. Control Reservoir.
79. Cover for Resistance Grid.
80. Oil Tank.
81. Slide Valve Reducing Valve.
82. No. 2 Junction Box.
83. Signal Valve.
84. Sand Box.
85. Electro-Pneumatic Sander.
86. Coupler.
87. Hose Couplings.
88. Pilot.
89. Main Air Reservoir.
90. Hook for Safety Chains.
90-A. Cable Connecting A. C. Trolleys.
90-B. No. 2 Master Controller.
90-C. No. 2 Automatic Brake Valve.
91. Third-Rail Shoe Beams.
92. Third Rail Shoe Bracket.
93. Journal Box.
94. Truck Frames.
95. Magneto for Speed Indicator.
96. Motor Suspension Springs.
97. Spring Hanger.
98. Elliptical Springs.
99. Wheel Pocket Cover.
100. Main Driving Wheel.
101. Third-Rail Shoe Cylinder.
102. Third-Rail Shoe Fuse Box.
103. Main Casting for Third-Rail Shoe.
104. Third-Rail Shoe.
105. Bell.
106. A. C., D. C. Change-Over Switch Heater Circuit.
107. Fuse Box, Heater Circuit.
108. Governor Valve for Emergency Control Reservoir.
109. Three-Way Cock Emergency Control Reservoir.
110. Emergency Control Reservoir.
111. Slide Valve, Reducing Valve.
112. Balancing Transformer (Back of S. T. and D. T. Switches).
113. Combined Strainer and Drain Cup.
114. D. T. Switch No. 1 Heater Circuit.
115. S. T. Switch Heater Circuit.
116. No. 1 Set Resistance Grids.
117. No. 1 Transformer.
118. Whistle.
119. Governor Air Brake.
120. Distributing Valve.
121. No. 1 Blower Motor Fan Casing.
122. No. 1 Blower Motor.
123. No. 1 Air Compressor.
124. No. 1 Air Compressor Motor.
125. Permanent D. C. Field Shunting Grid No. 1.
126. No. 1 Fuse Box.
127. Canopy Switch for No. 1 Blower Motor.
128. Canopy Switch for No. 1 Compressor Motor.
129. No. 1 Motor-Control Cut-out.
130. No. 1 A. C., D. C. Change-Over Switch.
131. Water Tank.
132. Air Connection to Motors.
133. Motor Leads for No. 1 and No. 2 Motors.
134. Axle of Main Driving Wheels.
135. Upper Torque Rod.
136. Center Pin.
137. Lower Torque Rod (long).
138. Trap Doors Over Motors.
139. Heater Circuit Leads.
140. Air-Brake Piping.
141. Motor Armature.
142. Motor Field Frame.
143. No. 1 Oil Circuit Breaker.
144. Bus Line Socket Heater Circuit, No. 2 End.
145. Bus Line Socket Heater Circuit, No. 1 End.
146. Quill.
147. Tool Box.
148. Bumper Block.
149. Motor Suspension Cradle.
150. Spring Hanger.
151. Equalizer Spring.
152. Brake-Shoe.
153. Steam-Heating Line.
154. Equalizer Bar.
155. Series Transformer for A. C. Ammeter No. 3 and No. 4 Motors.
156. Preventive Coil, 100 Volts, 250 Amps. (back of No. 59).
157. Field Shunting Resistance (back of No. 58).
158. Series Transformer for A. C. Ammeter, No. 1 and No. 2 Motors.
159. Armature Spider.
160. Air Inlet to Transformer.
161. Air Inlet to Resistance Grids.
162. Third-Rail Shoe Leads.
163. Gage—Control Line Pressure.
164. Support for Motorman's Seat.
165. D. C. Wattmeter.
166. Blind Lights.
167. D. P., D. T. Switch for Battery.
168. D. P., D. T. Switch for Battery.
169. S. P., S. T. Switch for Motor-Generator Set.
170. Snap Switch for Motor Generator Set.
171. Insulators Supporting A. C. Trolley Cable.
172. Shunt for D. C. Ammeter Motors, No. 1 and No. 2.
173. Lower Torque Rod (short).
174. Motor Suspension Hanger.
175. Steam-Hose Coupling.
176. Brake Cylinder.
177. Foot Push-Button Switches.
178. Air Conduit.
179. Shunt for D. C. Ammeter Motors, No. 3 and No. 4.
180. Motor Leads for No. 3 and No. 4 Motors.
181. D. T. Switch, No. 2 Heater Circuit.
182. Independent Brake Valve No. 2.
183. Third-Rail Shoe Unlock Cylinder.

feeder through the circuit breaker to the bus bar. Upon the next bridge these conditions are reversed, so that each auxiliary feeder is divided into four mile sections.

Both rails of all tracks are bonded by means of No. 0000 compressed terminal flexible bonds placed around the fish plates

ELECTRIC LOCOMOTIVES.

These locomotives were illustrated in this journal in May, 1906, page 184, and reference can be made to that article for details of mechanical construction as at present we will but briefly outline the general mechanical features and consider more fully the electrical apparatus, which was but briefly touched upon before.

The specifications under which the locomotives were built required that each should be able to handle a 200-ton train in a service requiring stops about every 2.2 miles, operating on a schedule of over 26 miles per hour. They were also to be able to haul the same weight train at from 65 to 70 miles per hour and a 250-ton train at 60 miles per hour. It was required that gearless motors should be used and that all the weight of the motors should be carried on springs. Since the locomotives are to operate on 600 volt direct current part of the time the specifications called for four motors, in order that they might be operated in the usual series parallel relation.

The two-truck type of locomotive was adopted, after careful consideration, as being the one best adapted to meet the conditions imposed. The underframe is necessarily of very heavy construction as it has to carry the full power of the locomotive from the center pins. It is located as low down as possible in order to get a direct pull from the draw bar. The cab is built up of a framework of Z-bars and covers the whole of the underframe.

The running gear consists of the two trucks, each mounted on four 62 in. driving wheels, and spaced with centers at 14 ft. 6 in. The armature of the motors is mounted on a spool which surrounds the driving axle but does not bear upon it. This spool is carried in bearings on the field frame and is connected to each of the driving wheels by seven large pins, projecting from the flanges on the ends, which fit into corresponding pockets formed in the wheel center. The pins do not fit tightly in the pockets, there being a clearance left for the insertion of helical springs, which are wound with their turns progressively eccentric. These springs are put in place under compression, both longitudinally and horizontally. By this method all of the power from the motor is transferred to the wheels through a yielding connection. The weight of the motors is carried on a steel frame entirely distinct from the truck and pivoted over the journal boxes. From this frame the weight is carried by springs on which the lugs of the field structure rest. The adjustment of these springs determines the portion of the weight that is carried by them, the remainder being supported by the armature quill or spool. The backward torque is transferred to the truck frame through rods, which permit a certain amount of vertical motion in the motor.

Armature Winding.—The active armature winding is closed upon itself and is not connected directly to different commutator sections, as is usually the case in direct current motors. It is, however, indirectly connected to the commutator through the preventative leads, which are a feature of the Westinghouse design of single phase motor. The active winding consists of several coils in each slot with one turn per coil. The function of the preventative coil or leads is to reduce to a low value the short circuit current caused when the brush passes from one commutator segment to the next. These leads serve the same function as preventative coils used in alternating current work when passing from one tap to another of the transformer. In fact the armature in one sense may be considered as a transformer with a lead brought out from each coil to the contact piece, the various contact pieces being assembled together to form a commutator.

There are several brushes per holder and both brushes and holders resemble closely those used for direct current work.

Field Winding.—The field winding is of the compensated type and is arranged in two circuits, viz., the main field coils, which

are placed around projecting poles on the field core and produce the active field flux, and the compensating field coils, which are placed in slots in projecting pole faces and serve to oppose the armature magnetomotive force and neutralize the reactance of the armature. The compensating coils remain at all times in series with the armature circuit, whether the machine is being

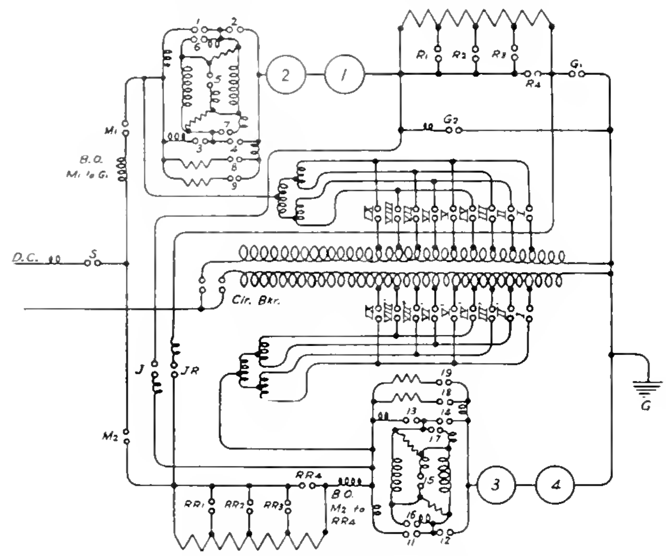


DIAGRAM OF LOCOMOTIVE CIRCUITS.

operated by a A C or D C current. Since during normal direct current operation the field coils receive twice as much current per armature ampere as when using alternating current, and since the active field coils in each motor are joined permanently in series and only two leads pass from the field frame for this purpose, two motors are operated as a unit and the separate field circuits of these motors are placed in series or parallel, as desired, according to the current being used.

Controller Circuits.—One of the illustrations shows a diagram of the locomotive connections. In direct current operation the four motors are arranged in two groups, and during acceleration these groups are connected in series and then in parallel. During alternating current operation each separate motor unit receives power at variable voltage from the auto transformer. The switches are interlocked so that the circuits used exclusively for one type of current cannot become active when the other type is used.

Referring to the illustration showing a diagrammatic view of the locomotive circuit and considering first the direct current operation, switches 2, 3 & 12, 13 or 1, 4 & 11, 14, according to the direction of operation, are closed so that the main field circuits of each motor are connected in series with their respective armatures. For starting, switches S, M 1 and J R are closed.

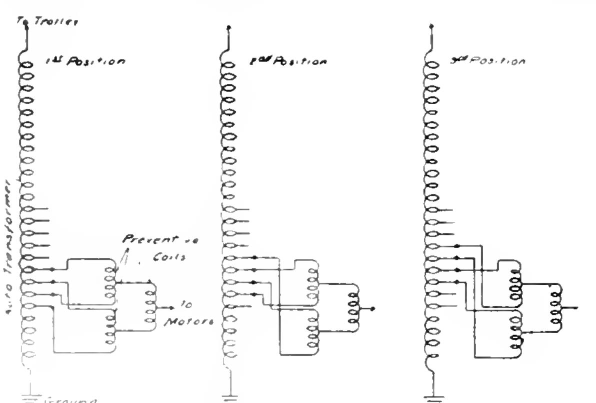
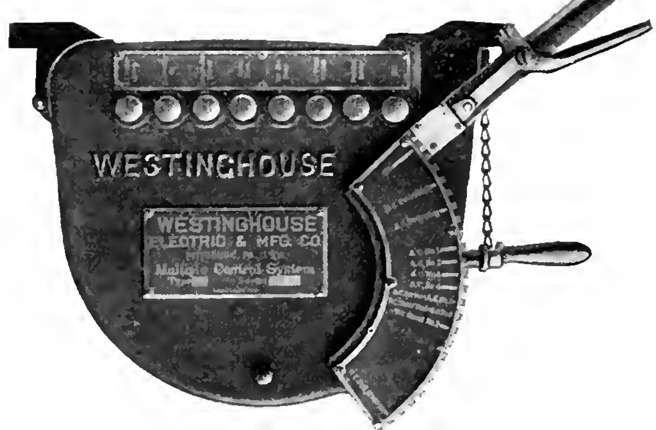


DIAGRAM SHOWING METHOD OF SHIFTING AUTO-TRANSFORMER CONNECTIONS.

thus connecting two complete motor units in series with each other and with eight sections of resistance. As the speed increases switches R 1, R 2, R 3, and R 4 of one motor unit and switches RR 1, RR 2, RR 3 and RR 4 of the other unit are closed in succession, thereby increasing the voltage in each unit until the two are in series across the line without resistance. Switches 8 and 18 are then closed, thus placing a resistance in shunt with the field winding and thereby weakening the fields and increasing the speed. This is followed by closing switches 9 and 19, which further weakens the field and increases the speed. The speed at this point is considerably more than ½ the normal running speed. The next movement of the controller handle opens switches 8, 9, 18, 19 and Jr and closes switches J, G 1 and M 2, thus putting each motor unit in series with four resistance sections and in parallel with each other. It will be noted that the transfer from series to parallel is accomplished without opening any motor circuit and without short circuiting either motor unit. Higher speeds are then obtained by cutting out the resistance from the circuits by closing switches R 1, RR 1, etc.

During alternating current acceleration no resistance whatever is used, the speed changes being obtained by variable voltages from different taps of the auto transformer. The first movement is the closing of switches 6, 7 & 1, 4, or 3, 2 and 16, 7 & 11, 14 or 12, 13, according to the direction desired. This places the main field circuits of the two motors of each unit in parallel, thus giving one-half the field magnetism per armature ampere, as is given during direct current operation.

There are six running points with alternating current, each corresponding to a certain voltage impressed upon the motor circuits. For changing from one voltage point to another on each auto transformer, use is made of three small preventative coils. These coils are essentially auto transformers having a ratio of 2 to 1. Referring to the diagram showing this connection it will be observed that the motor unit receives current from the middle connection of the coil whose terminals are joined to the middle points of two other coils, the outer terminals of which are connected to taps on the main transformer. In shifting from one running point to another the lower tap is opened and a connection is made with a tap four points higher up and so continued, each time the lower connection being opened and the



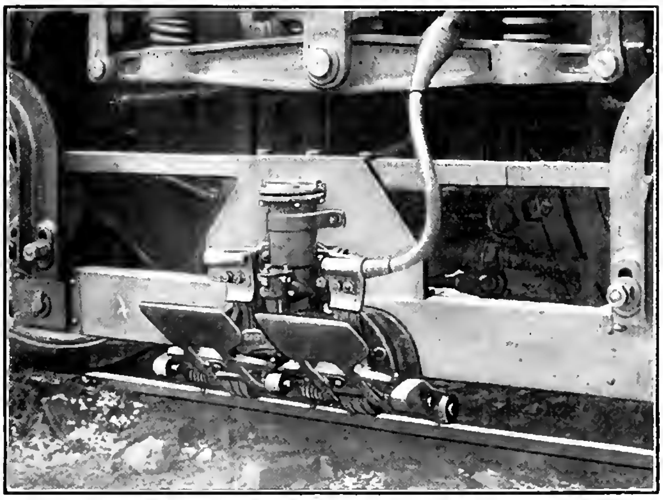
TOP VIEW OF MASTER CONTROLLER.

new one closed at the top. Thus at no time is the motor circuit opened or the transformer winding short circuited.

Switches.—Each switch used in the motor circuits is operated by compressed air of 80 lbs. pressure, which is controlled by valves operated by an electromagnet, which in turn is controlled by a current from a 20 volt storage battery, the battery being charged by an induction motor driven direct current generator. The switches are arranged in groups and are conveniently located in each side of the center aisle of the locomotive. The location and arrangement of all the apparatus is shown in the large illustration giving a cross section of the locomotive.

The master controller, a top view of which is shown, is of the drum type, the drum shaft being revolved by means of a handle resembling the throttle lever on a steam locomotive. The reverse lever is mechanically interlocked with the operating lever of the controller, so that all circuits must be dead before the reverse lever is thrown from one position to another. The row of knobs seen in the rear of the top of the controller are push

buttons for performing certain operations not connected with the main controller lever or reverse handle, such as putting the trolleys and third rail shoes up and down; resetting the main line circuit breakers; operating the track sanders and ringing the bell. These different operations are actually performed by compressed air, the push button merely completing the circuit from the storage battery to the proper air valve magnets. The bell and sanders can also be controlled by the foot pedals shown in one of the illustrations. In front of the motorman are air pressure gauges, a speed indicator, a direct current ammeter, an alternating current ammeter and an electrical pyrometer, the latter instrument indicating the temperature of the motors.



THIRD RAIL SHOE AND PNEUMATIC ATTACHMENTS.

One of the illustrations shows the third rail shoe and its mechanism. This shoe must be capable of being held by spring pressure downward against an over-running rail, or upward against an under-running rail, and must also be capable of being lifted to clear any ordinary obstruction along the track where the third rail is not used. The shoes are hinged from a framework, which in turn is hinged from the face plate on the truck frame. The shoe frame may be thrown outward in a horizontal plane, or upward to an angle of 45 degs. from the horizontal by a toggle joint arrangement, which is operated electro-pneumatically. When the framework is in a horizontal position each shoe is held in place by a spring, so that it resists motion in either an upward or downward direction. The control of this mechanism is interlocked with the alternating current trolley, so that when the trolleys are up the shoes are also up and when the shoes are down the trolleys are also down; the trolleys can, however, be pulled down when the shoes are up.

In the cab are two air compressors driven by compensated motors of the same type as the main motors. The circuits to these are controlled automatically by the air pressure. There are also two motor driven centrifugal blowers, which furnish air for cooling the high potential transformers, rheostat, and the four large motors.

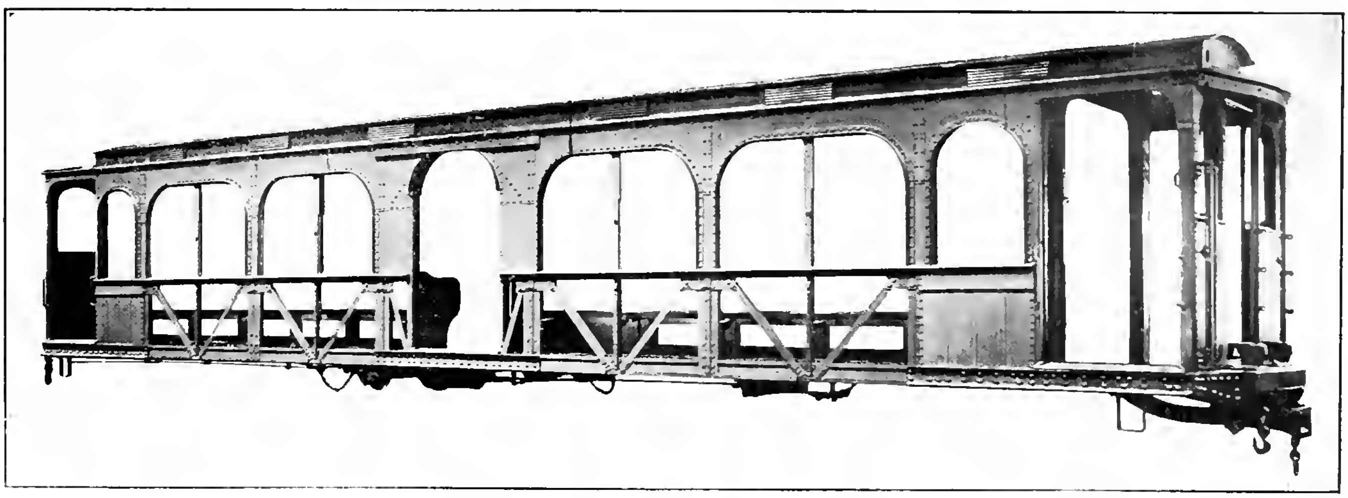
This air enters the motors at the armature shaft, passes around and between the armature windings, flows outward through the field coils and escapes through perforated caps in the frame of the motor. In addition to keeping the motor cool this scheme also prevents the entrance of any dust or dirt.

The locomotives measure 34 ft. 6 in. over bumpers and weigh approximately 90 tons. The motors have a normal rating each of 250 h.p. or 1,000 h.p. per locomotive. They were built by the Baldwin Locomotive Works and the Westinghouse Electric & Mfg. Company.

ALL-STEEL PASSENGER CARS.

HUDSON COMPANIES.

The Hudson Companies are receiving the first order of fifty all steel passenger cars, which are to be operated in their system of tunnels and subways. The design of these cars was preceded by a most careful study of the difficult conditions under which they are to be operated, which demand that the cars shall be absolutely fireproof, that they shall be arranged for the most convenient and rapid loading and unloading, and that they shall be as light in weight as possible in order to permit of the greatest acceleration and thus be capable of running on a high speed schedule with stops varying from 1/3 to 1/2 mile apart. A study of the accompanying drawings and description will show that all of these conditions have been fully complied with.

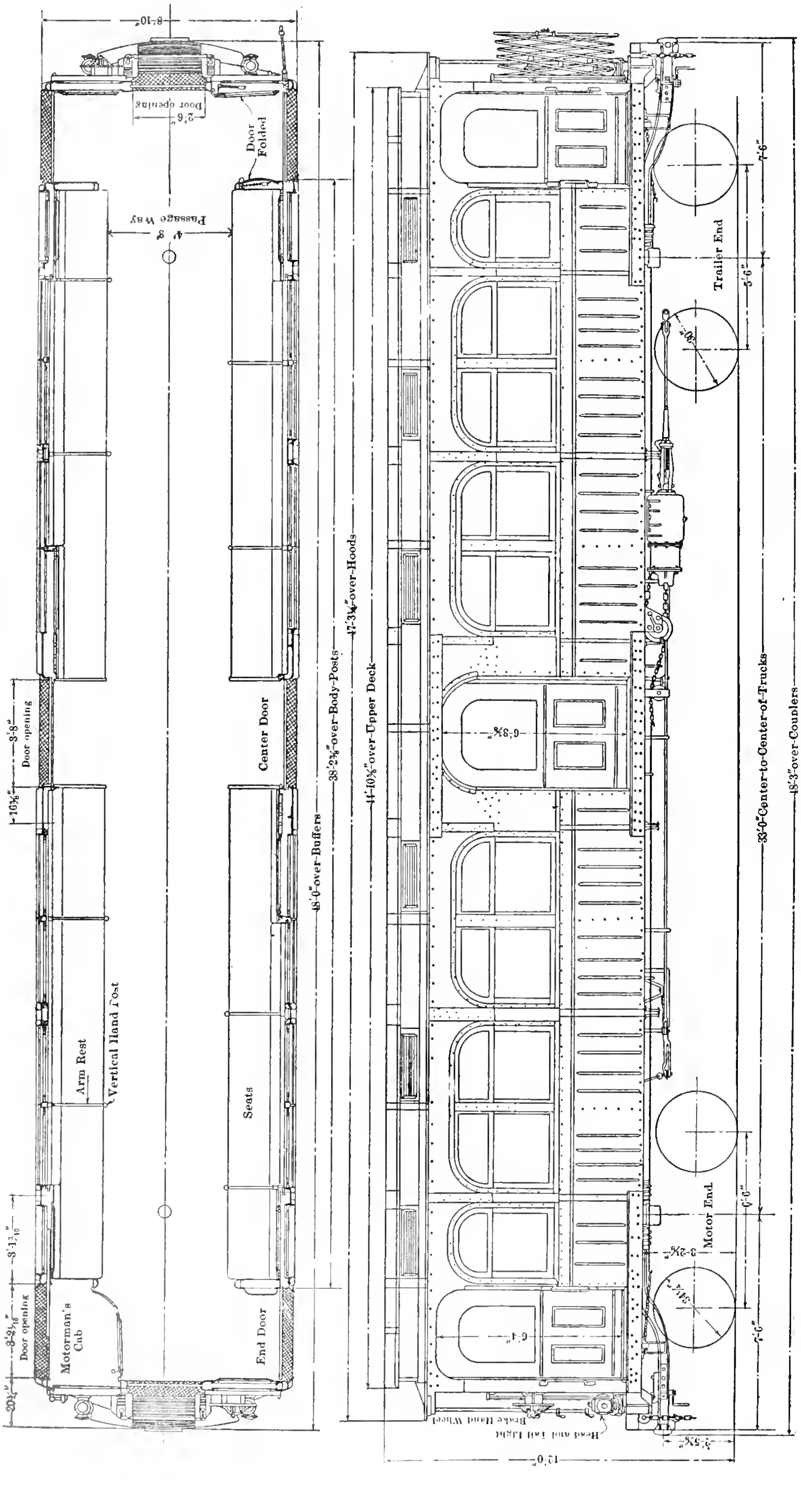


FRAME OF ALL-STEEL CAR BODIES—HUDSON COMPANIES.

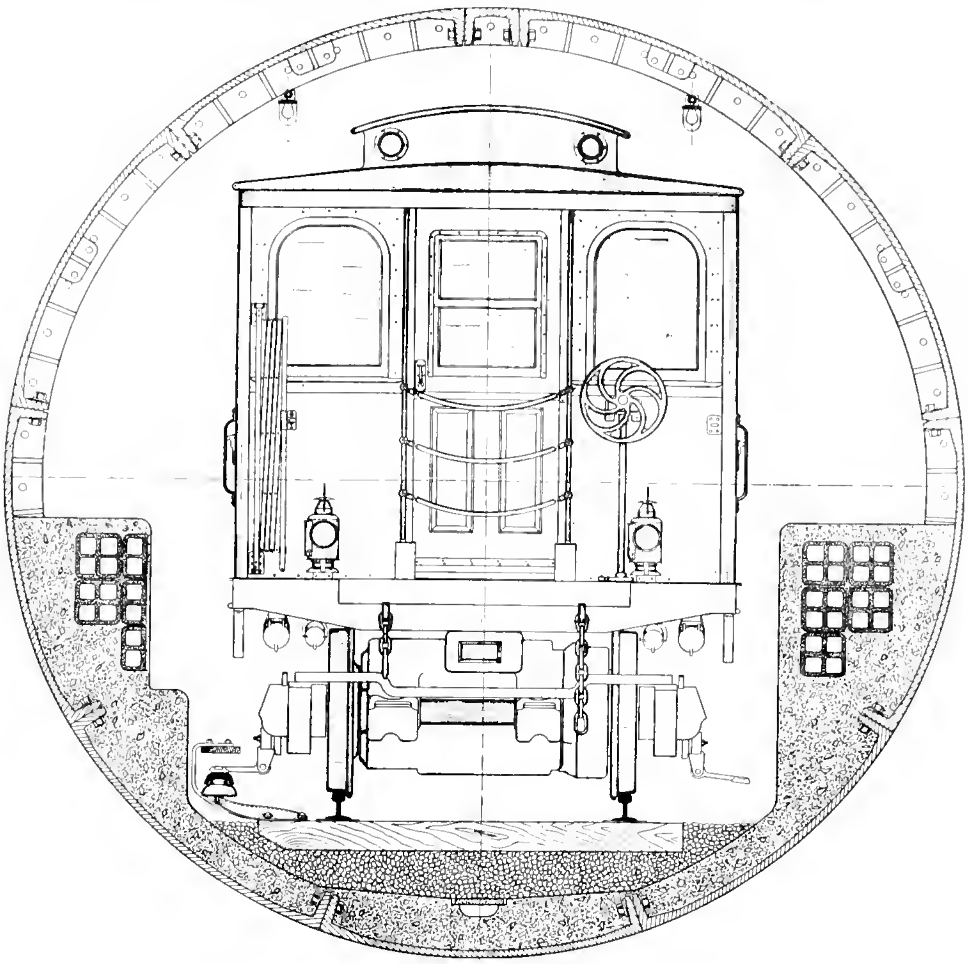
The tunnels and subways of this company are located under and on both sides of the Hudson River and consist first of a twin tunnel extending from Fulton and Church streets, New York City, below the Hudson River, to a point near the Pennsylvania Railroad terminal. From this point they continue as subways parallel with the river, with stations at the Erie and Delaware, Lackawanna & Western Railroad terminals. At a point midway between the latter two stations a pair of tunnels pass below the river, emerging in New York at Christopher and Greenwich streets, thence continuing as a subway along Christopher to 9th street, and thence under 6th avenue to 33rd street. There will also be a branch running west as a subway from near the Pennsylvania Station in Jersey City.

Work on all parts of this system is now in progress and it is expected that the section from Christopher and 9th streets, New York, to the D. L. & W. terminal in Hoboken, will be in operation by January 1, 1908. This will then be followed by other sections as rapidly as they can be completed. The second section to be put in operation will probably be the subway on 6th avenue.

The service in these tunnels will consist of trains of as many cars as are demanded, to a maximum of eight, running at as



PLAN AND ELEVATION OF ALL-STEEL CARS WITH CENTER DOORS—HUDSON COMPANIES.



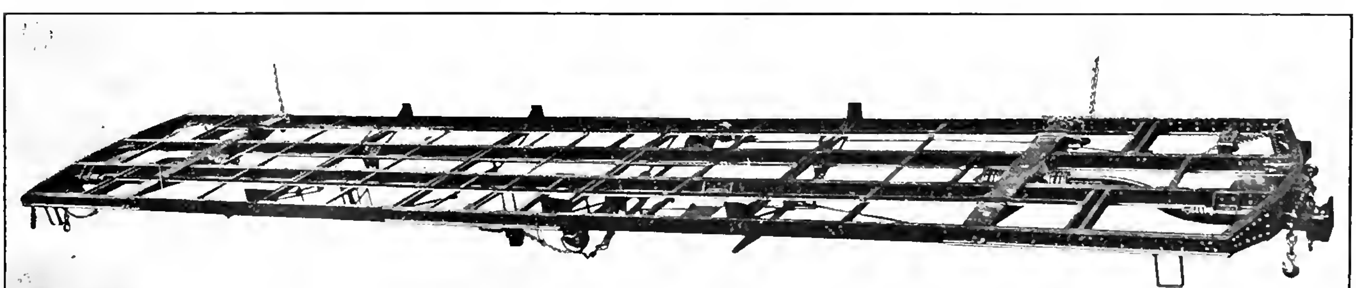
SECTION OF HUDSON RIVER TUNNELS SHOWING CLEARANCE OF ALL-STEEL CARS.

short headway as safety will permit. These trains will operate on the multiple unit system, taking current from a third rail. Direct current of 650 volts pressure will be used, being furnished by a large power house located in Jersey City, with such sub-stations as are needed. The whole system is of the double track type with loops at the ends.

The feature of the problem requiring the greatest amount of attention is the one of handling the enormous crowds of people during the rush hours, morning and evening, and of this, the matter of rapid loading and unloading the trains is the most difficult. It is on this point that the present rapid transit facilities in New York City are the weakest. It is believed, however, that the arrangement of platforms and design of cars, which are to be used by the Hudson Companies, will eliminate most of this trouble. At terminals, where the larger number of people are to be handled, it is planned to have a platform on either side of the trains, one for loading and the other for unloading, and the cars have been designed with a wide door in the center of the car in addition to the large doors at either end, and the end bulkhead of the car has been omitted to give free access to the end doors. Thus by opening the three doors on one side of the car and having an unobstructed platform, the car can be unloaded very rapidly and at the same time the doors in the opposite side being opened will allow it to fill in the same length of time without any confusion or crowding.

The illustrations show the appearance and construction of the cars, as well as a section of the tunnel below the river, in which they will be operated. From this it will be seen that the car is of the all steel type, being absolutely fireproof, even to the seat cushions and backs, which are covered with a metal fabric in place of the usual rattan.

The desire to use a center door made it impossible to design the car with the section below the window sills in the form of a plate girder, as has been done in most of the all steel short haul cars. It is also undesirable to support the car entirely from plate girders in the underframe, as this would add too greatly to the weight. Hence the car body and its load is supported entirely by a truss frame occupying the whole side of the car between the plate and sill. This truss is arranged in five panels, the center door occupying the middle panel. The bottom chord of the truss is a 6 in. channel forming the side sill and extending continuously from end to end of the car and the top chord



UNDERFRAME OF ALL-STEEL CARS—HUDSON COMPANIES.

END VIEW OF ALL-STEEL CAR—HUDSON COMPANIES.

is a similar channel forming the side plate. The vertical parts of the truss are 8 in. channel posts, spaced uniformly and placed between the pairs of windows. Below the window sills these posts are braced by diagonal members to the bottom chord and above the windows they are reinforced by angle irons and steel plates, which arch over the pairs of windows and are riveted to the top chord. At the center door the top and bottom chords are reinforced by bulb angles, as is also the bottom chord below the end doors. This truss is designed to carry the entire weight of the car with the full passenger load and give a fiber stress not to exceed 12,000 lbs. per square inch in any part.

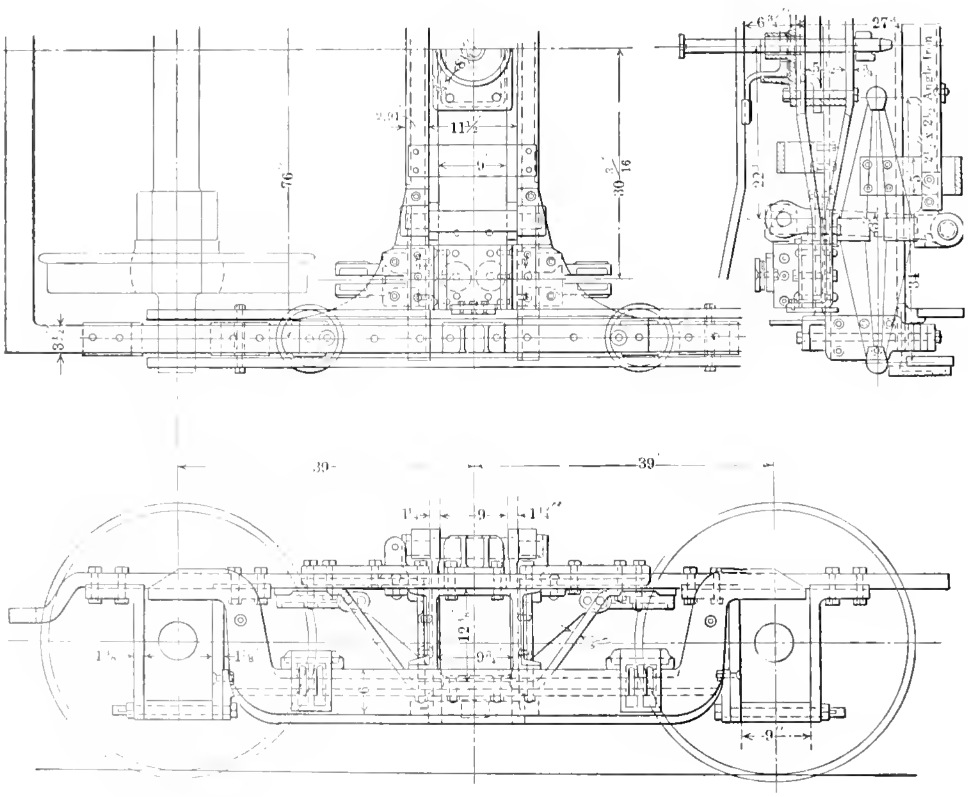
Underframe.—The underframe consists of 6 in. I-beams acting as center sills and running continuous from end to end of the car. The side sills are the 6 in. channels already mentioned. The bolsters are of the built up type and carry the spring draft gear in the center between the sills. The needle beams, of which there are four between the bolsters, are composed of angles set between and secured to the longitudinal sills. King posts are secured to the center sills at the needle beams and truss rods with turnbuckles transfer the load from the center sills to the

INTERIOR OF ALL-STEEL CAR—HUDSON COMPANIES.

side truss. The end sills have been made unusually strong and consist of vertical plates reinforced by angles top and bottom, being curved to the contour desired for the end of the car. Connection is made to the center and side sills by heavy cast steel knee pieces. There are also two heavy steel castings riveted to the center sills, which extend upward about 8 in. above the buffer casting and act as a stop to prevent the telescoping of the car platforms in the event of a collision.

Side Sheathing.—The sheathing of the ends and sides of the car consists of steel plates 1/16 in. thick. These plates are riveted to the truss frame after the latter is in place and none of the rivets which hold the frame in place pass through the sheathing; thus it is possible to remove the sheathing plates for repairs without disturbing the truss.

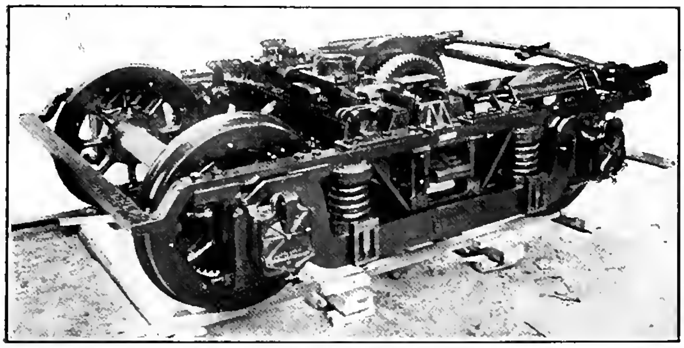
The roof is supported by angle iron carlins bent to the proper contour and spaced about 14 in. apart. To these are riveted the 1/16 in. steel plates which form the roof. These plates are coated on both sides with lead and all seams and rivets are soldered to make them water tight.



MOTOR TRUCK—ALL-STEEL CARS FOR THE HUDSON COMPANIES.

Doors.—The six doors in the car are all of the sliding type, being supported by ball bearing hangers running on a track at the top. A piece of rubber hose is attached to the edge of the doors to prevent the possibility of pinching the fingers or catching the clothing of the passengers. The doors are of pressed steel and are operated by air cylinders, the piston having a stroke of about 15 in. and a rack and pinion being used to increase the movement. The operation of the air cylinders is controlled from air valves located at the ends of the car. A system of electric signals is provided, which indicate by means of a bell or light in the motorman's cab when all of the doors are closed and every door must be closed before the motorman can receive the signal to start the train.

Interior Finish.—The interior is finished with 1/32 in. steel plates as head lining and side panels. The window guides and post covers are also steel plates pressed to the proper form. The floor is made of monolith cement laid on galvanized Keystone iron. The top surface of the floor is coated with a layer of



VIEW OF MOTOR TRUCK—HUDSON COMPANIES.

cement containing about 30 per cent. carborundum, which forms a hard wearing surface and gives a secure footing.

The seats are all longitudinal and consist of a steel framework on which rest cushions and backs covered with a metallic fabric. The seats were manufactured by the Hale & Kilburn Mfg. Co. Partitions, which consist of steel plates extending to a little above the shoulder of a seated passenger, are provided as shown in the plan of the car. The top edge of the partition is fitted with a 1 in. pipe bent to the proper curve. These partitions are high enough to form a support to the passenger and thus obviate the disagreeable effect of the sudden starting and stopping of the trains. A vertical hand rod is located at each of the seat partitions, extending from the seat to the ceiling fixture which supports the hand strap rod. These posts are intended as a convenient support for standing passengers.

Each car is lighted with thirty 10 candle-power incandescent lamps. There are two lamps in each vestibule, and switches are provided so that the current may be transferred from the two vestibule lamps in the end occupied by the motorman to the two lamps in the destination signals. In addition to the regular lighting equipment there is an emergency equipment of four lamps in each car, which are supplied from a 60 volt storage battery. In case the power should go off the line the emergency lamps would be continued to be lighted from the battery. The battery consists of 30 cells having a discharge rate of 1½ amperes for eight hours and is so connected that it normally floats on the line. The batteries were furnished by the Gould Storage Battery Company. The head and tail lights of the train, there being two of each, are the ordinary type of oil marker lamps. The heaters are of the panel type placed below the seats and were furnished by the Consolidated Car Heating Company.

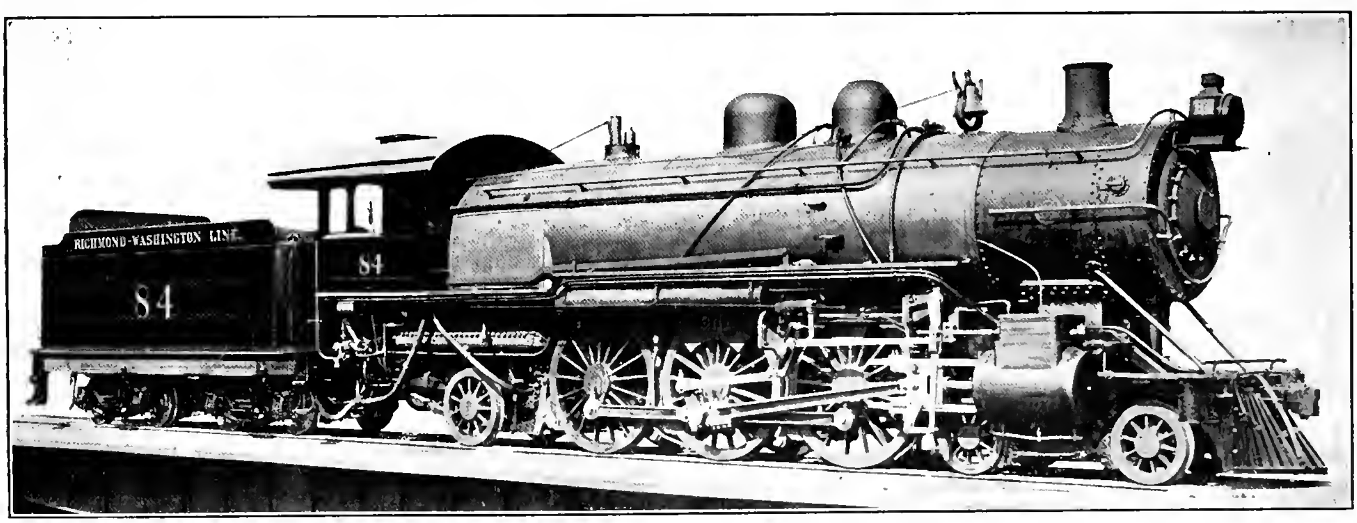
Control Equipment.—The latest type of Sprague-General Electric multiple unit control is used and a number of improvements have been made in the material used for insulation in order to render it fireproof. The control equipment of each car includes a current limit relay, which provides automatic acceleration of the train with predetermined current in the motors. This relay, however, does not prevent the operation of the master controller at less than the predetermined current if desired.

Each car is provided with two 160 h.p. motors known as the GE No. 76. This is a specially designed motor for this service and follows very closely the GE 66, the difference being in the armature speed and some improvements in the commutation.

Trucks.—The motor and trailer trucks were built by the Baldwin Locomotive Works and are shown in the accompanying illustration. They are of the M. C. B. passenger type, and the motor trucks have wheels with cast steel spoke centers and rolled steel tires held on by double retaining rings. One wheel on each axle has an extended hub upon which the driving gear is shrunk. The wheels of the trailing truck are of the solid steel forged type and were made by the Standard Steel Wheel Company. The motor truck has a wheel base of 6 ft. 6 in., 34¼ in. wheels and a 6 in. axle, while the trailer truck has a wheel base of 5 ft. 6 in., 30 in. wheels and a 4¾ in. axle.

These cars were designed and built under the direction of Mr. L. B. Stilwell, consulting electrical engineer, and Mr. Hugh Hazelton.

Of the 50 cars now being delivered 40 of the car bodies were built by the American Car & Foundry Company and 10 by the Pressed Steel Car Company.



HEAVY PACIFIC TYPE LOCOMOTIVE—RICHMOND, FREDERICKSBURG & POTOMAC RAILROAD.

PACIFIC TYPE LOCOMOTIVES.

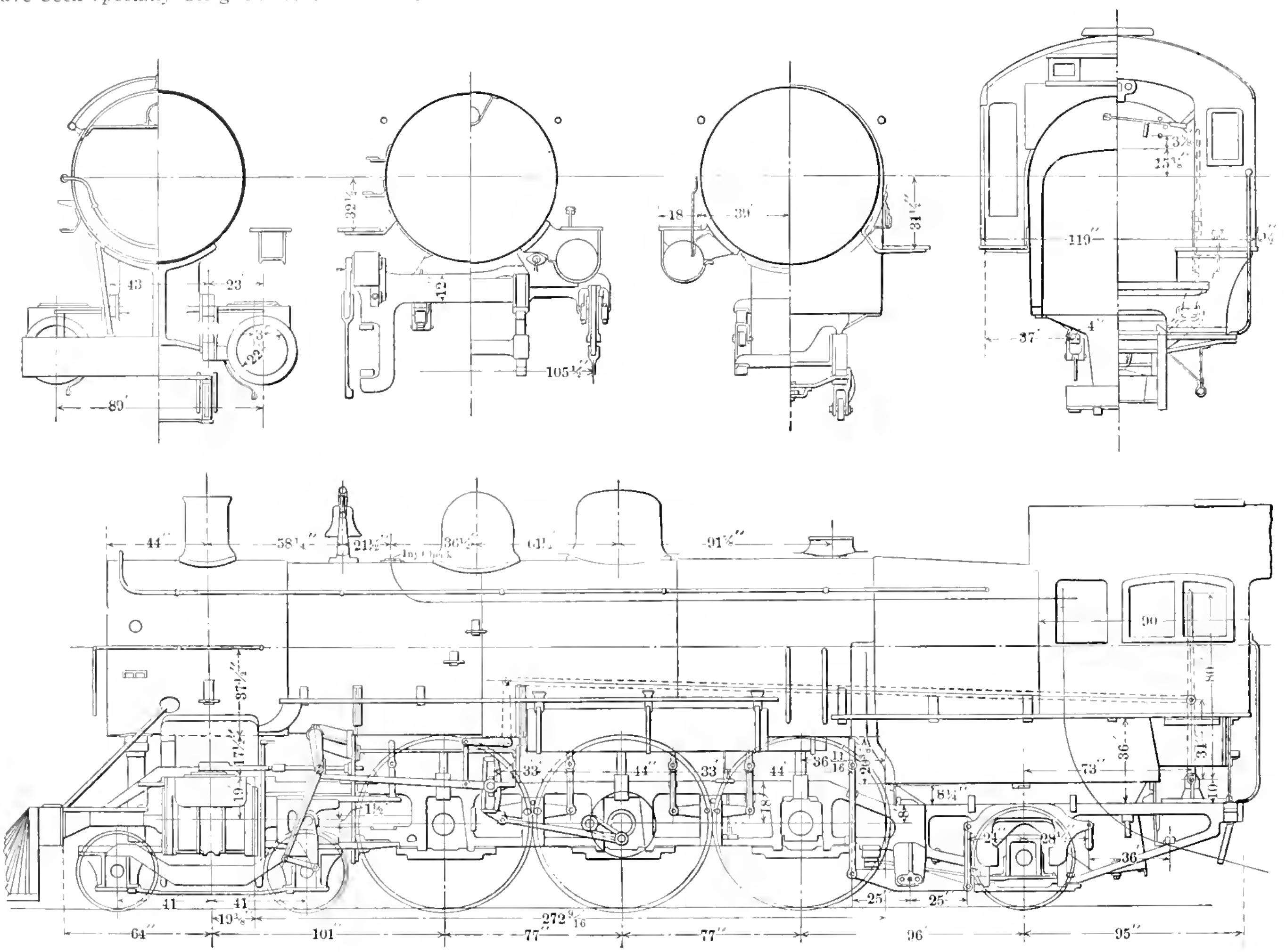
Richmond, Fredericksburg & Potomac R. R.

The Baldwin Locomotive Works has recently delivered to the Richmond, Fredericksburg & Potomac Railroad six large Pacific type locomotives, which will be used for both freight and passenger service on that road. These engines have a large boiler capacity, a steam pressure of 200 lbs., 22 x 28 in. cylinders and 73 in. driving wheels. They weigh 230,800 lbs. and have a tractive effort of 31,100 lbs.

This railroad company operates about 125 miles of road, form-

ing a direct connection between Richmond, Va., and Washington, D. C., running through Fredericksburg, Va. The controlling grade northbound is .6 of one per cent. and southbound .8 of one per cent. The passenger traffic is very heavy, the trains often consisting of twelve or thirteen Pullman cars, but the freight service is practically all first-class, the average speed of freight trains on the line being about 35 miles per hour. These locomotives are intended for both classes of service and will handle 1,450 tons northbound and 1,100 tons southbound. In passenger service they are expected to haul the heaviest train on a schedule of 3 hrs. 30 min. between Richmond and Washington, the distance being 116 miles. There are five stops on the run and slow speed at several points. It is expected that after some track improvements are finished these locomotives will be put on a schedule of 2 hrs. 30 min. between Richmond and Washington, having but three intermediate stops. The locomotives have been specially designed for this service and an examination which would indicate that an excellent grade of fuel is to be used. The boiler is of the straight top type 74 in. in diameter at the front ring and contains 318 2¼ in. tubes 21 ft. long. The water spaces around the firebox are but 4 in. wide at the mud ring, indicating that the water supply is of good quality.

The general features of the design are evident from the photograph and general elevation. Balanced slide valves are used, being operated by Walschaert type of valve gear, the design of which, differing from other recent Pacific type locomotives, is arranged for hanging the links from a frame cross tie between the first and second pair of drivers instead of on a longitudinal support outside the front driver and extending between two frame cross ties. The motion is transferred from the plane of the link inward to the center line of the valve by a rocker arm supported from the guide yoke. This throws the center line of the valve 3 in. inside the center of the cylinders. The frames are 5 in. in width and are of cast steel, which material is also used for



ELEVATIONS AND SECTIONS OF HEAVY PACIFIC TYPE LOCOMOTIVE, R. F. & P. R. R.

of their dimensions and ratios would indicate that with the proper fuel they will easily be able to do the work.

The most noticeable feature of this design is found in the point of greatest importance for a high speed heavy passenger locomotive—*i. e.*, capacity of the boiler. An examination of the ratios will show that in this respect these locomotives are considerably above the average Pacific type. The B. D. factor (tractive effort × diameter of drivers ÷ total heating surface) is 560, a figure considerably below that ordinarily found in the Pacific type locomotive and one which, with two or three exceptions, is as low as any locomotives of this type on our record. Of those which are lower might be mentioned the large Pacific type for the Lake Shore & Michigan Southern Railroad, illustrated in our September issue, which gave 550, and the Michigan Central locomotive, illustrated in 1904, page 347, which gave 555. The other ratios concerned with the heating surface are also considerably above the average. The grate area is possibly somewhat smaller than usual for the amount of heating surface

the driving boxes and wheel centers. The rear truck is of the Rushton type with inside journals. A liberal use has been made of the Tate flexible stay-bolt in these locomotives.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	31,100 lbs.
Weight in working order	230,800 lbs.
Weight on drivers	143,750 lbs.
Weight on leading truck	46,850 lbs.
Weight on trailing truck	40,200 lbs.
Weight of engine and tender in working order	350,000 lbs.
Wheel base, driving	12 ft. 10 in.
Wheel base, total	32 ft. 8 in.
Wheel base, engine and tender	61 ft. 11½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.62
Total weight ÷ tractive effort	7.65
Tractive effort × diam. drivers ÷ heating surface	560.00
Total heating surface ÷ grate area	82.90
Firebox heating surface ÷ total heating surface, per cent.	4.64
Weight on drivers ÷ total heating surface	34.90
Total weight ÷ total heating surface	56.10
Volume both cylinders, cu. ft.	12.30
Total heating surface ÷ vol. cylinders	334.00
Grate area ÷ vol. cylinders	4.03

CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
Kind of valves	Bal. Slide
WHEELS.	
Driving, diameter over tires	73 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	9½ x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6 x 10 in.
Trailing truck wheels, diameter	42 in.
Trailing truck, journals	8 x 12 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	74 in.
Firebox, length and width	108 x 66 in.
Firebox plates, thickness	5/16, ⅜ and ½ in.
Firebox, water space	4 in.
Tubes, number and outside diameter	318—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	3,917 sq. ft.
Heating surface, firebox	190 sq. ft.
Heating surface, total	4,107 sq. ft.
Grate area	495 sq. ft.
Center of boiler above rail	112½ in.
TENDER.	
Wheels, diameter	33 in.
Journals, diameter and length	5 x 9 in.
Water capacity	6,000 gals.
Coal capacity	12 tons

INSPECTOR'S REPORT FORM FOR NEW CARS.

The Seaboard Air Line has a convenient form for the use of its inspectors, in reporting the receipt of new cars from the builders. In addition to the general information at the top of the sheet, provision is made to show the wheel numbers, the dates they were cast and the pressure required to force each one on the axle. Each sheet is arranged to show this wheel data

SEABOARD AIR LINE RAILWAY
PORTSMOUTH, VA.
CAR INSPECTION No........ .....

Built by.......................... ....
No. Cars....................*Capacity*........ .. ..*Kind*.... ....
Class...........*Nos*...........*to*...........*inc*...........*Journals*....... .....
Wheels...................................*Axles*.................................
Springs................................*Bearings*.................................
Couplers.................................*Air Brake*.. ....
Brake Beams...................... .....*Draft Gear*. ....
For.................................. ....
Reported to...... ....*Date*... ....

Car Number	Wheel Number	Cast Date On Wheel	Tonnage	Wheel Number	Cast Date on Wheel	Tonnage	Maker's name
L. Wt.							

Number of Cars previously accepted.......... . ...
Number of Cars accepted this date......................... ....
Number Cars accepted, Total................. ....

Gen. Mechanical Inspector.
SECRETARY

and the light weight for six cars. The reports are forwarded to the superintendent of motive power who, at a glance, can see just how many cars have been delivered on the order. The sheets are filed as part of a permanent record and can be referred to any time. The form was devised by Mr. B. O. Yearwood, one of the inspectors, to whom we are indebted for information.

ORGANIZATION.

A very common conception of organization is that it is an arbitrary arrangement by which orders are transmitted by various steps, through different groups of officials, from the man at the head of the organization to the many men who form the rank and file and do the actual work. Many graduates have shown that they believe that the way for a man in a high position to get a thing done is to order it done. Poor and inefficient administrators may do it that way. The successful administrators are men who act on the principle that their business is to administer unto those below them in the organization in three ways. First, by putting them into such places and under such conditions that they can do their best; second, by giving them orders necessary to show what is expected of them; and, third, by enlisting their wills as well as their bodies and minds in the work of the organization so that they will do their best. The first and third of these, the average graduate has never seriously thought of. He sees in the administrative officer the man who orders. The successful administrator finds his time so thoroughly filled with the first and third kinds of administration, with putting each man in the place and under the conditions most favorable to his effectiveness, and with enlisting in the service the will of the man, that orders fill but a small part of his horizon.

The men near the top in an organization normally do the most difficult work. Normally they are the men who work most intensely and for the longest hours. In the great organization with which I am connected, the civil service of the United States, this is so commonly recognized that it calls forth no comment to see the rank and file leave at four-thirty and come exactly at nine, while others who are in responsible control of the organization work early, late and strenuously.—*Mr. John Fillmore Hayford, from Commencement Day Address at the Clarkson Memorial School of Technology.*

Locomotives as Fire Engines.—The Pennsylvania Railroad has fitted out the switch engines working in its yards at Pittsburg and Altoona with fire pumps and hose and has trained the crews to act as a fire department. A system of whistle signals has been arranged to indicate in what part of the yard the fire breaks out, and all locomotives within a certain radius are uncoupled from their trains and rushed to that point. Yard masters and train directors arrange to give the necessary orders to provide a clear track to the scene of the fire and the signals are set indicating the routes for the locomotives to take. At a recent fire the first engine had a stream working within two minutes after the alarm sounded and within seven minutes nine engines were on the scene.

Wages and Prices of Food.—The annual investigation of the Bureau of Labor into wages and the retail prices of food shows that in the principal manufacturing and mechanical industries of the country wages were 4.5 per cent. higher in 1906 than in 1905. The hours of labor per week were 5.5 per cent. lower and the number of employees 7 per cent. greater. These figures apply only to wage workers and do not include salaried employees. The retail prices of food, weighed according to consumption in representative workingman's family, were 2.9 per cent. higher in 1906 than in 1905, hence the purchasing power of an hour's wage was greater in 1906 than the preceding year. Compared with the ten years from 1890 to 1900 the purchasing power of an hour's wage in 1906 was 7.3 per cent. greater.

Tests of Vanadium Steel.—The United Steel Co., Canton, Ohio, gives the following results of tests made on vanadium steel from a 30-ton heat poured at its plant. The tests were made of various portions of the steel subjected to different heat treatments. The figures in each case are the average of three tests:

Tensile strength, lbs	150,917	167,500	166,667	187,083
Elastic limit, lbs	143,333	161,667	160,833	181,667
Elongation, per cent	15	15	14.3	9.6
Reduction of area, per cent	54	51.6	50	30

Railroad Y. M. C. A.—It is stated that in the U. S. there are 231 railway associations in charge of the Y. M. C. A., but directly controlled by the railway management. Two hundred and twenty-one of these have a total membership of 87,860 and are growing at the rate of more than 10,000 a year. The current expenses of 214 associations were $930,573; the value of the buildings owned is more than four million dollars. The total attendance at 214 houses was 44,370. Fifteen new buildings were erected for this purpose last year at a total cost of $318,000. Twenty new buildings have already been assured for the coming year.

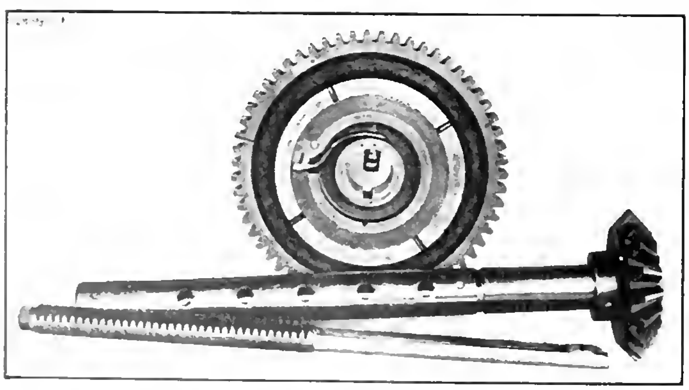
36-INCH BULLARD VERTICAL TURRET LATHE.

The Bullard Machine Tool Co., of Bridgeport, Conn., has for years been specializing in the manufacture of vertical boring and turning mills of both single and double head types, the latter construction, with its absolute independence of feeds for each head, having obviously greater productive capacity than single head machines of equal size. The tool equipment for this type of machine is simpler than for the ordinary horizontal turret lathe construction, due to the fact that the main turret head on the cross rail has a full universal movement, both vertical and horizontal, throughout the entire range of the machine, expensive overhanging cutters being thereby rendered unnecessary.

The proposition of equipping the smaller size machines with two heads, similar in design and construction to those in use on the larger tools, met with success only in a measurable degree, for there were many operations where only one head (where two were mounted in the conventional manner) could be brought into play unless the second head was swiveled to an excessive angle on the rail and extended from its supporting saddle to a point where the two tools could be used in a close proximity. The efficiency of the head thus used was materailly reduced and feeds and speeds were of necessity reduced to a point below the danger line—very little, if any, ultimate saving in time resulting from the use of two heads in this manner.

Mr. E. P. Bullard, Jr., in 1900 conceived the idea of practically swiveling that part of the rail carrying the second head to an angle of 90 degrees with the cross rail and in that way attaining the desired end—the saving in time made possible by the use of two tools working in close proximity on pieces of small diameter.

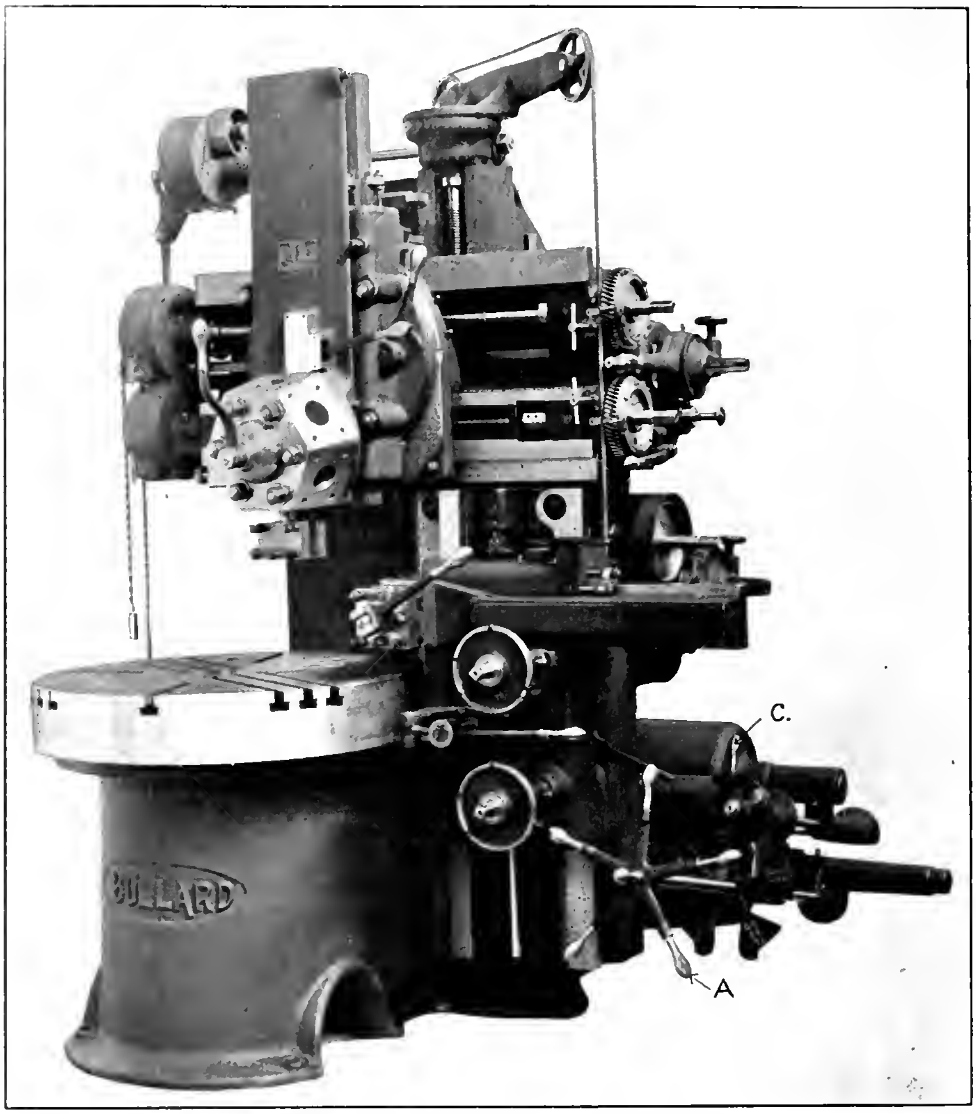
Six of these tools were built and placed in operation in various plants. For a period of four years they were under close observation with a view to possible improvement, the result being that an entirely new machine, embodying the side head feat-



CONSTRUCTION OF FRICTION CLUTCHES.

ure in a much improved form, was placed upon the market in 1904. Feature after feature has been added—each with a view to greater productive capacity—until in the present machine the makers believe they have the most highly developed machine tool of its class on the market.

As now constructed the machine consists of an exceptionally rigid bed of vertical box construction, internally braced against



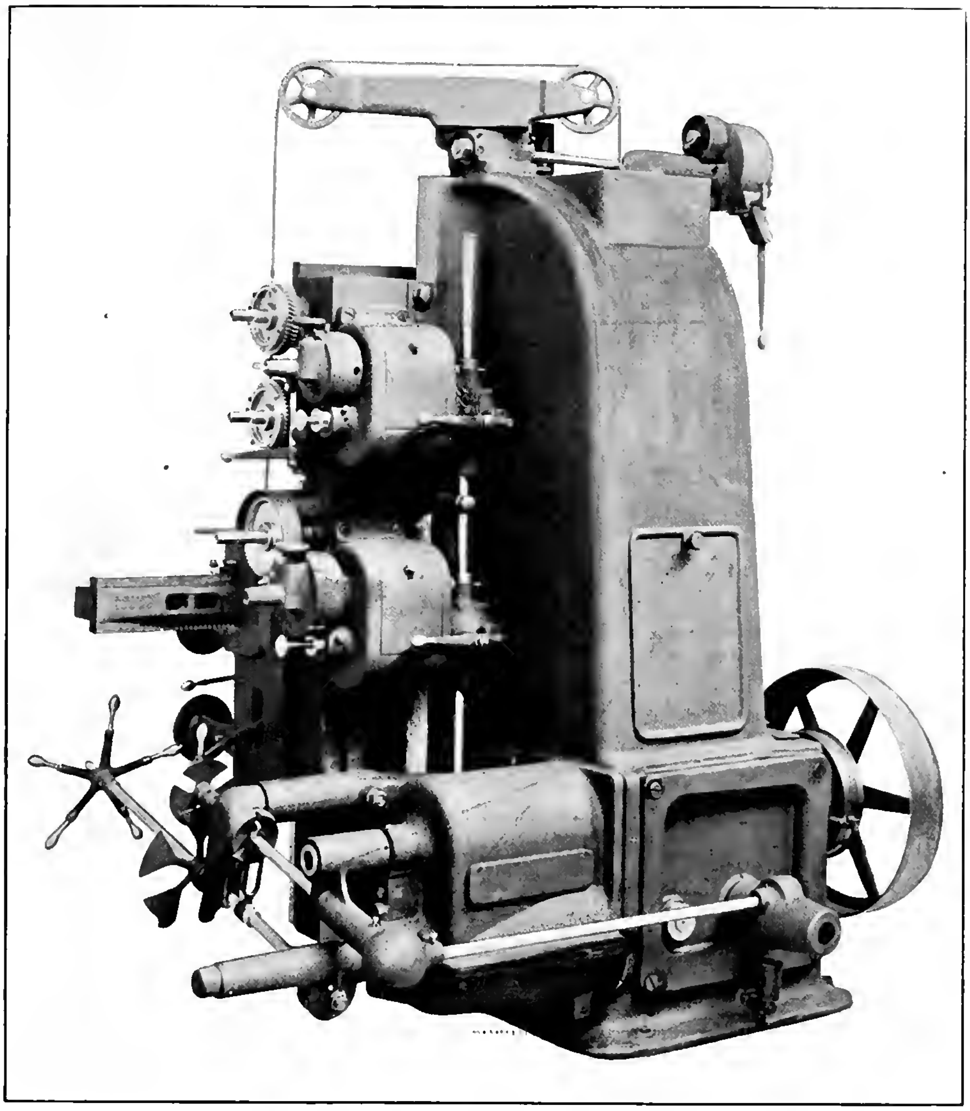
BULLARD VERTICAL TURRET LATHE—FRONT VIEW

all strains incident to its duty, on which are mounted a cross and vertical rail. The extension of the bed base serves to support a table spindle of large proportions and permits of an exceptionally efficient system of lubrication whereby the spindle is at all times immersed in oil.

The machine is of the single belt speed and gear box construction, fifteen speeds being obtained by a set of gears and friction clutches, encased in the speed box shown at the side of the machine, in combination with three sets of reduction gears mounted as a unit inside of the bed and transmitting the power to the table by a spur pinion and internal gear. A notable feature of the drive is that there is no step up in the gear train, the first motion shaft running the fastest of all, with a continuous drop between it and the table.

Speed box changes, of which there are five, are obtained by revolving the pilot wheel A, each spoke indicating a speed which is engaged only when that spoke is in a vertical position. The quick acting brake is also actuated by lifting this lever. Headstock changes are controlled by the lever C which has three positions. The movements of these levers are all interlocking, to make conflict between them impossible. The engagement of the positive clutches in the headstock reduction gearing can only be effected when the brake is set, and the brake cannot be released until the desired change has been fully accomplished;

the speed box changes cannot be made unless the brake is disengaged, and the clutches are thus protected from harm. While protecting the driving mechanism from breakage, due to careless handling, this interlocking system in no way interferes with the rapid manipulation of the machine—any speed being obtainable without stepping from the working position.



REAR VIEW OF BULLARD VERTICAL TURRET LATHE.

The feed works for each head, while identical in design, are absolutely independent of each other. The eight changes are obtained, in two series of four, by opposed cones of gears constantly in mesh, "diving" keys being set by two handles on each feed box. Graduations showing the feed in engagement are conveniently located.

It will be seen from the photographs that there are no pull gears on the various feed rods. The change trom vertical to cross rail, or vice versa, on the vertical head is effected by the engagement of the drop worm, centrally located between the rods. The same changes in direction of feed in the side head are obtained by clutches actuated by the horizontal lever shown between the rods on this part. Breakage of gearing by collision of the two heads is obviated by safety points incorporated in the feed train which, while simple, are very efficient.

Micrometer index dials graduated to thousandths are adjustably mounted on each feed rod and a scheme has been worked out in connection therewith which renders simple the reproduction of various diameters and sizes and at the same time does not present the limitations—mechanical and otherwise—of the automatic knock-off. It consists of indicators numbered to correspond to the turret faces which are set to the proper micrometer reading, as the correct dimensions of the first piece are reached. Calipering and measuring for depth are thus obviated on all but the first piece.

The handling of the main head by power, for rapid movement, is conveniently obtained through the key-handles shown at the right end of the cross rail, these handles operating plungers which pass entirely through the speed rod and screw and actuate clutches in the boxes shown at opposite end of rail. This mechanism is driven from the first motion shaft and its speed is constant and has no relation to the speed or movement of the table.

The maintenance of turret alignment has been solved effectively by placing adjustable taper gibs on both front and back bearings, the saddle being solid square locked throughout. The rails—both cross and vertical—are practically a unit and may be adjusted vertically, by power, to obtain the greatest efficiency of slides on work of varying length.

The construction of the friction clutches used throughout the machine is shown in one of the photographs. The spider is keyed to the shaft and the gear revolves freely thereon until the friction is engaged by forcing out the pin which actuates a spring lever. While this type of friction is practically self-adjusting the small wedge shown at fulcrum point has recently been added, rendering easy the adjustment, should any be required. Provision is made in the speed box construction whereby the adjusting points may be brought in line with a removable cap and no disassembling whatever is required.

Lubrication of all parts subject to wear has received careful attention; all gearing is in a constant bath of oil, gauges being conveniently placed which indicate the proper level to be maintained. The machine has a capacity of 36" in diameter and 24" in height and weighs 11,300 lbs. net.

Care of Locomotives in New York State.—One section of a new law which went into effect in New York State on September 1 states that, "it shall be the duty of every corporation operating a steam railroad within this State, and of its directors, managers or superintendents, to cause the boiler of every locomotive used on such railroad to be washed out as often as once every thirty days, and to equip each boiler with, and maintain thereon at all times, a water glass, showing the height of water in the boiler, having two valves or shut-off cocks, one at each end of such glass, which valves or shut-off cocks shall be so constructed that they can be easily opened and closed by hand; also to cause such valves or shut-off cocks and all gauge cocks or try-cocks attached to the boiler to be removed and cleaned whenever the boiler is washed out pursuant to the foregoing requirements of this section; also to keep all steam valves, cocks and joints, studs, bolts and seams in such repair that they will not at any time emit steam in front of the engineer, so as to obscure his vision. No locomotive shall hereafter be driven in this State unless the same is equipped and cared for in conformity with the provisions of this section; but nothing here contained shall be construed to excuse the observance of any other requirement imposed by this chapter upon railroad corporations, their directors, officers, managers and superintendents Every corporation, person or persons operating a steam railroad and violating any

of the provisions of this section, shall be liable to a penalty of one hundred dollars for each offense, and the further penalty of ten dollars for each day that such violation shall continue. The board of railroad commissioners shall enforce the provisions of this act.'

Locomotive Regulations in Canada.—The Board of Railway Commissioners in Canada has issued an order that all steam locomotives fitted with an extension smoke-box shall have a netting of a mesh not larger than 2½ per in. of No. 10 B. W. G. wire, to be placed in the smoke-box so as to extend completely over the aperture through which the smoke escapes. On engines with diamond stacks the netting must not be less than 3 per in. of No. 10 wire. The back of all ash pans shall be fitted with either a sheet iron damper, or screen netting dampers. This netting shall be inspected at least once a week and the report of the inspector be turned in to the commission. A penalty of $25 for each offense is made. No company is allowed to burn lignite coal on its locomotives under a penalty of $25 for each offense.

PERSONALS

Mr. R. E. Fulmer has resigned as master mechanic of the Illinois Central R. R. at Paducah, Ky.

Mr. J. A. Lewis has been appointed master mechanic of the Monterey division of the Mexican Central Railway.

Mr. M. M. Meyers has been appointed division master mechanic of the Missouri Pacific Ry. at De Soto, Mo.

Mr. C. O. Osborn has been appointed foreman of shops of the Chicago and Northwestern Ry. at Fond du Lac, Wis.

Mr. R. L. Doolittle has been appointed assistant master mechanic of the Central of Georgia R. R. at Macon, Ga.

Mr. I. T. James has been appointed master mechanic of the Missouri Pacific & Iron Mountain System at McGehee, Ark.

Mr. L. T. Gibbs has been appointed electrical engineer of the Baltimore & Ohio R. R., to succeed Mr. W. D. Young, resigned.

Mr. C. A. V. Axen, foreman of shops of the Chicago and Northwestern Ry. at Green Bay, has been transferred to Antigo, Wis.

Mr. S. H. Lewis, foreman of the Seaboard Air Line at Norfolk, Va., has been appointed master mechanic of the Virginian Railway.

Mr. W. F. Canavan has been appointed general foreman of locomotive shops of the Missouri, Kansas & Texas Ry. at Parsons, Kan.

Mr. George J. Duffy, master mechanic of the Canadian division of the Michigan Central R. R., with office at St. Thomas, Ont., has resigned.

Mr. B. F. Elliott has been appointed assistant master car builder of the Mexican Central Ry., with headquarters at Aguascalientes, Mexico.

Mr. R. D. Gibbons, master mechanic of the Mexican Central Railway at Monterey, has been transferred to the same position at Aguascalientes.

Mr. Thomas Yeager, roundhouse foreman at Bloomington, Ill., has been appointed master mechanic of the Illinois Southern Ry. shops at Sparta, Ill.

Mr. F. W. Peterson, master mechanic of the Chicago & Northwestern Ry. at Fond du Lac, Wis., has had his headquarters removed to Green Bay, Wis.

Mr. E. S. Fitzsimmons, general foreman boilermaker of the Erie R. R., has been appointed master mechanic at Galion, O.

Mr. R. A. Johnson has been appointed master mechanic of the Chihuahua division of the Mexican Central Railway.

Mr. F. W. Thomas, engineer of tests of the Atchison, Topeka and Santa Fe Ry., has been appointed supervisor of apprentices, with office at Topeka, Kan.

Mr. J. J. Tatum has been appointed superintendent of the freight car department of the Baltimore & Ohio R. R., with headquarters at Baltimore.

Mr. T. H. Russum has been appointed superintendent of the passenger car department of the Baltimore & Ohio R. R., with headquarters at Baltimore.

Mr. W. A. Bedell has been appointed master mechanic of the Missouri Pacific & Iron Mountain System at Van Buren, Ark., succeeding Mr. B. Donahue.

Mr. Charles James, master mechanic of the Erie Railroad at Galion, Ohio, has been appointed master mechanic at Port Jervis, N. Y., vice Mr. G. A. Moriarity.

Mr. A. H. Gairns, master mechanic of the Denver & Rio Grande R. R. at Denver, Colo., has been appointed master mechanic at Salt Lake City, Utah.

Mr. H. C. Ettinger has been appointed master mechanic of the Decatur & Springfield division of the Wabash Railroad, with headquarters at Springfield, Ill.

Mr. R. D. Smith, mechanical expert of the New York Central Lines, has been appointed assistant superintendent of motive power of the N. Y. C. & H. R. R. R.

Mr. E. E. Chrysler, general foreman of shops of the Chicago, Rock Island & Pacific Ry. at Chickasha, I. T., has been appointed division master mechanic at that point.

Mr. E. I. Dodds, mechanical engineer of the Pullman Company, has been appointed assistant mechanical superintendent of the Erie R. R., with headquarters at Meadville, Pa.

Mr. J. F. Bowden, formerly general foreman at Trinidad, D. C., has been appointed master mechanic of the Baltimore & Ohio R. R., with headquarters at Parkersburg, W. Va.

Mr. H. A. Beaumont has been appointed general foreman of the car department of the Baltimore & Ohio R. R., with jurisdiction over the Mt. Clare shops and Baltimore terminals.

Mr. B. H. Gray, master mechanic of the New Orleans Terminal, has been appointed superintendent of motive power of the Mobile, Jackson & Kansas City Ry., with office at Mobile, Ala.

Mr. M. S. Monroe, heretofore general foreman of the Chicago, Lake Shore & Eastern Ry., has been appointed master mechanic, with office at Joliet, Ill., and the former position has been abolished.

Mr. A. S. Grant, who recently resigned as master mechanic of the Missouri Pacific Ry. at De Soto, Mo., has been appointed master mechanic of the Texas Central R. R. at Walnut Springs, Texas.

Mr. E. D. Andrews has been appointed division master mechanic of the Chicago, Burlington & Quincy Ry. Lines West of the Missouri River at Sterling, Colo., to succeed Mr. F. Newton, resigned.

Mr. A. J. Poole, master mechanic of the Seaboard Air Line at Atlanta, Ga., has been appointed superintendent of motive power, with office at Portsmouth, Va. Mr. Poole succeeds Mr. R. P. C. Sanderson, resigned.

Mr. J. J. Hanline, master mechanic of the Birmingham division of the Seaboard Air Line, has been appointed master mechanic at Atlanta, Ga., succeeding Mr. A. J. Poole, promoted.

Mr. John Charlton, foreman of shops of the Chicago & Northwestern Ry. at Antigo, Wis., has been appointed division master mechanic at Chicago, to succeed Mr. L. M. Carlton, resigned.

Mr. W. F. Ackerman, superintendent of shops of the Chicago, Burlington & Quincy Ry. at Havelock, Neb., has been appointed assistant superintendent of motive power at Lincoln, Neb.

Mr. Thomas E. Layden, assistant engineer of tests of the Atchison, Topeka & Santa Fe Ry. at San Bernardino, Cal., has been appointed engineer of tests, with headquarters at Topeka.

Mr. O. Stewart has tendered his resignation as superintendent of motive power and equipment of the Bangor & Aroostook R. R. to take effect on October 1, at which time he will have completed 60 years in railway service.

Mr. W. L. Calvert, master mechanic of the valley division of the Missouri Pacific and Iron Mountain system at McGehee, Ark., has been transferred to Cotter, Ark., as master mechanic of the Memphis and White River division.

Mr. F. E. Fox, master mechanic ot the Colorado and Nebraska divisions of the Chicago, Rock Island & Pacific Ry., at Goodland, Kan., has been appointed master mechanic of the first division of the Denver & Rio Grande R. R., with headquarters at Burnham station, near Denver, Colo.

Mr. E. F. Needham has been appointed superintendent of the locomotive and car department of the Wabash Railroad, vice Mr. J. B. Barnes, retired. Mr. Needham entered the railroad service as an apprentice at the Fort Wayne shops of the Wabash Railroad in 1880 and has been with that company during his whole career. His headquarters will be at Springfield, Ill.

Prof. E. R. Dewsnup, who has been in charge of the railway courses at the University of Chicago for the past three years, has been appointed professor of railway administration at the University of Illinois at Champaign. This is a new position created for the purpose of enlarging and developing the new school of railway engineering. Professor Dewsnup will be associated with Dean W. F. M. Goss in developing this new school. Professor Dewsnup was born in England of American parentage, and received his education at the University of Manchester and the Royal Technical College of Manchester. After receiving his degree he spent considerable time in studying the operation, construction and management of railroads in the United Kingdom, France and Germany, and was for a time an officer on an English railway. He also visited the United States to study the railway system of this country, remaining here about a year. He then returned to England, but after a time was brought to the University of Chicago about three years ago to take charge of the railway courses.

BOOKS

Kahn System Standards. A hand-book of practical calculations and applications of reinforced concrete. Bound in paper; 4¾ x 7¾ in., 106 pages. Published by the Engineering Department, Trust Corcrete Steel Company, Detroit, Mich. Price $1.50.

The object of this hand-book is to present to the user tables and information in such a form as to be immediately available for use in design. These tables are founded on scientific formula which has been approved by the best engineering practice. The data presented are obtained from an extensive experience in reinforced concrete covering the design and construction of over a thousand structures of all kinds. This book will be found of value to any one interested or concerned with reinforced concrete structures.

Brakes for Tramway Cars. By Henry M. Sayers, M. I. E. E. 5½ x 8½ in. Cloth. 76 pages. Published by D. Van Nostrand Co., 23 Murray street, New York. Price $1.50.

This book considers in detail the subject of brakes, especially as applied to street cars. The first chapter deals with the function of the brake and considers the coefficient of friction. The second, third and fourth chapters deal with wheel brakes of various forms, considering the efficiency and the influence of rail conditions, sanding, etc. Following this are chapters on braking practice, both mechanical and magnetic; on adjustment and maintenance of brakes and conclusions as to the choice and use of brakes. The final chapter gives constants and formulæ for calculations on brakes, accelerations and retardations. The book is illustrated.

The Work of the Running Department. By Henry Simpson. Bound in paper, 5½ x 8½ in. 106 pages. Published by the Swindon Engineering Society, Swindon, England. Price forty cents.

This book is a reprint of a lecture given by the author before the Swindon Engineering Society, which has been published in pamphlet form in order to meet the demand for extra copies. It has attracted much favorable comment in England and is considered of great value to the locomotive department. It supplies highly specialized information which, it is stated, has never before been published in connected form. It includes many blank forms for reports that are used on different English railways, both for inspection and repair of locomotives, and gives very complete information concerning the organization of different departments. The matter of proper design of roundhouses, water stations, influence of good and bad boiler waters, and the proper handling of power at the terminals are all discussed.

CATALOGS.

Snow Plows.—The Wilder Snow Plow & Mfg. Co., Worcester, Mass., is issuing a small catalog illustrating and describing snow plows for steam and electric railways, one design being a radial plow for work on sharp curves. Both single and double-ended plows are illustrated.

Electrical Apparatus.—The General Electric Company is issuing a number of new bulletins, among which might be mentioned Bulletin No. 4518 on the subject of electric hoists, which illustrates and gives tables of sizes of many different designs. Bulletin No. 4512 is on the subject of manhole fuse boxes, and No. 4520 deals with engine type continuous current generators.

Nut and Bolt Fasteners.—The American Nut and Bolt Fastener Company, Pittsburg, has issued catalog No. 5, which describes in detail the various types of Bartley nut and bolt fasteners which are used in railroad work. These different styles meet all the requirements for cars, locomotives and rail fastenings. Robert Spencer & Co., 20 Vesey street, New York, is the eastern agent, and Christopher Murphy & Co., 164 Dearborn street, Chicago, the western agent for the above company.

Prairie Type Locomotives.—The American Locomotive Company has just issued the tenth of its series of catalogue pamphlets, which illustrates and describes the Prairie type locomotives built for various roads. This pamphlet contains half-tone illustrations and the principal dimensions in tabulated form of fifteen different designs of locomotives of this type, ranging in weight from 136,000 to 245,000 pounds. The usual style of pamphlet adopted by this company is followed, beginning with the description of this class of locomotives and presenting the advantages which it offers for fast freight and passenger service.

Metropolitan Injectors.—The Hayden & Derby Mfg. Company, one of the subsidiary companies of Manning, Maxwell & Moore, 85 Liberty street, New York, is issuing an attractive illustrated catalog descriptive of its very complete line of injectors, ejectors, and jet apparatus. The catalog, in addition to describing in detail the action and construction of the different apparatus, also contains many excellent suggestions in connection with the selection of proper sizes and types for different conditions, as well as instructions to be followed in case of trouble, proper methods of connecting and operating, etc. Strainers, water heaters and other kindred apparatus are included in this catalog.

Draft Gear.—The Waugh Draft Gear Company, 1525 Monadnock Block, Chicago, Ill., is issuing an illustrated catalog descriptive of its apparatus. This gear consists of groups of straight spring steel plates which under compression are curved over oval surfaces by movable blocks separating each pair of groups at their ends. It is claimed that in curving these plates from the straight position an easy graded cushion is obtained; the increasing curvature of the plates under compression is attended by a frictional adhesion between their individual surfaces, which adds to their cushion capacity and retards the return to the straight position, thus reducing the recoil. The apparatus is shown in a number of sizes, as applied to both wooden and steel underframe cars.

CHAIN BELTS.—The Chain Belt Company, Park street and 11th avenue, Milwaukee, Wis., is issuing a general catalog, No. 35. This catalog, bound in cloth, contains 287 pages, and is a very complete work on the subject of chain belts. It is thoroughly illustrated and includes all information required for selecting chain belts for use in any kind of elevating, conveying and power transmitting machinery. Considerable valuable engineering matter in connection with this subject is included.

SUPERHEATED STEAM ON LOCOMOTIVES.—A large and very completely illustrated catalog, printed in English, is being issued by the Schmidt Superheating Company, Ltd., of Wilhelmshohe, Cassel, Germany. This catalog gives illustrations of a number of locomotives fitted with the Schmidt superheater, and also contains line drawings and complete descriptive matter of the designs of improved superheaters now being supplied, together with details of the cylinders, pistons and valves, especially designed for superheater locomotives. The results of many tests and of actual service with locomotives using highly superheated steam are included. Many of these are comparative tests with saturated steam engines and illustrate very clearly the large economy resulting from superheat. The Schmidt type of superheater has been applied to a total of 2,315 locomotives.

LOCOMOTIVE CRANES.—The Brown Hoisting Machinery Company, Cleveland, O., is issuing an illustrated catalog descriptive of locomotive grab bucket cranes. The illustrations show these cranes in operation, handling large amounts of ore, coal, sand, etc., at a rapid and economical rate. The grab buckets ordinarily used have a capacity of 24 cu. ft., or about 2½ tons of ore. Under their own power these cranes have the function of hoisting, rotating, traveling and of raising and lowering the boom. All of these functions, as well as the opening and closing of the grab bucket are under the control of one man. They are often used to push or pull cars and are equipped with sliding gears, so that the traveling mechanism can be thrown out of use and the crane hauled over the road at high speed. Cranes of this type have at many points proved to be very satisfactory for coaling locomotives and cleaning clinker pits.

CURTIS STEAM TURBINE GENERATOR.—The General Electric Company is issuing a very attractive pamphlet (No. 4531), which will be found of special interest to engineers on account of the information given therein regarding superheat, vacuum, economy, etc., and details of construction and operation of all parts of the Curtis turbine apparatus. The catalog is very thoroughly illustrated and the more important details are clearly described. Under the heading of "economy" a number of detailed tests are given of turbines from 1,000 k. w. to 9,000 k. w. capacity, which shows some remarkably high efficiencies. The efficiency curves are unusually flat, giving high figures at both overloads and light loads. This publication is typical of recent tendencies of large engineering firms to have their descriptive matter written by engineers and hence to contain matter of the highest engineering value.

BALDWIN LOCOMOTIVE WORKS.—This company is issuing two new pamphlets, one being "Record of Recent Construction" No. 63, containing illustrations and complete descriptive specifications of fourteen different locomotives of varied classes, which have recently been completed at its works. These include both passenger and freight locomotives of all types, principally for use on American Railways. A pamphlet of corresponding style is also being issued, which contains a description of the apparatus it has on exhibition at the Jamestown Exposition. This contains illustrations, specifications and a brief description of the different locomotives to the number of six, one of which is an electric; also two electric mine locomotives and several different designs of electric trucks. The exhibit of the Standard Steel Company, including rolled steel wheels, forgings and castings, is also described.

ELECTRIC HEATING AND COOKING DEVICES FOR MARINE USE, is the title of a handsome publication just issued by the General Electric Company. A ship's lighting plant, usually of more than ample capacity for intermittent load, offers at once an available source of supply, which, utilized for cooking, heating, etc., would provide numerous real and profitable conveniences with small increase in cost. The electric heater, on account of its compactness, neatness, easy regulation and simplicity, is ideal for stateroom use. The General Electric Company manufactures several forms, including luminous radiators and non-luminous air heaters. One or two-quart water heaters, electric wash bowls and electric shaving mugs are familiar conveniences, and electric flat irons, in sizes from three to twenty-four pounds, are supplied for the laundry. Among special devices particularly serviceable on shipboard may be mentioned electric soldering irons, glue pots, curling iron heaters, surgeon instrument sterilizers, heating pads, cigar lighters, etc.

TWINVOLUTE TURBINE PUMPS.—The Watson-Stillman Company, 25 Dey street, New York, is issuing sectional catalog No. 72, which is an assortment of sheets, selected from their large amount of printed matter, which relate especially to turbine pumps. This company has found that its great mass of catalog sheets, covering all classes of hydraulic machinery, has become too large to be given general distribution, so they have prepared a series of sub-divided catalogs, each of which deals with a special subject or class of machine. The catalog is thoroughly illustrated with line drawings and half tones and describes in detail both single and two-stage turbine pumps. These pumps are of a special and improved design, arranged for operation either horizontally or vertically, to be driven by gears, belt or direct connected to any prime mover. The results of a number of careful tests of different sizes of these pumps are included. A number of valuable tables in connection with the flow of water through pipes, equivalent water and mercury heads, power transmitted by belts, relation of horse power to water head, etc., complete the book.

NOTES

GOULD COUPLER COMPANY.—At a special meeting of the Board of Directors of the above company, Mr. F. P. Huntley was elected vice-president and general manager, and Mr. George G. Milne was elected secretary.

COMMONWEALTH STEEL COMPANY.—This company announces that it has moved into its new offices in the Pierce Building, opposite the Planters Hotel, St. Louis. It now occupies the entire southern wing of the sixteenth floor of that building.

FALLS HOLLOW STAYBOLT COMPANY.—This company announces that the fire which destroyed the greater portion of the building of its rolling mill, on September 13, did not damage the principal machinery to any great extent and that it is now in a position to promptly execute orders.

THE T. H. SYMINGTON COMPANY.—Mr. E. H. Symington, manager western sales of the above company, who was thrown from his horse and seriously injured a few months ago, has steadily improved and recently left for an extended trip around the world. Mr. Symington expects to be in his office at Chicago by the first of the year.

THE WM. POWELL COMPANY.—The increased demand for Powell's steam engineering specialties has made an enlargement of the plant of the above company at Cincinnati necessary. Plans are being prepared to erect buildings on the ground, 37 x 200 ft., recently acquired, and to increase the capacity of the power plant by 200 horse power.

AMERICAN BLOWER COMPANY.—This company announces that some recent installations which it has made, providing a circulation of air drawn over cooling coils, in the same manner as is usually used for heating, have been most successful during the recent hot weather. This was especially noticeable in foundries where it has often been necessary to curtail the production on account of the heat.

WILMARTH & MORMAN COMPANY.—Among the recent shipments of New Yankee drill grinders to railway shops, were one machine each for the A., T. & S. F. Ry., the I. C. R. R. and the Jamesville & Western R. R., two to the Baltimore & Ohio Railroad and six to the Intercolonial Railway of Canada. This company also announces that it is delivering a large number of these machines to general manufacturing shops throughout the world.

REPORT OF THE CHICAGO PNEUMATIC TOOL CO.—The semiannual report of the above company clearly indicates its very satisfactory financial condition. It states that the profits of the half year's business are $507,528, which after deducting two quarterly dividends, a liberal depreciation on buildings and tools, reserve for bond interest and sinking fund and over $10,000 for developing new tools, leaves a surplus of $190,819. This gives the company a total surplus of over one million dollars.

COURT DECISION ON NOLAND PATENT.—The outcome of the suit brought by the Westinghouse Electric & Mfg. Co. against the Prudential Insurance Company for infringement of the Noland patent in a generator owned by that company and manufactured by the Bullock Electric & Mfg. Co., is an opinion by Judge Lanning of the U. S. Circuit Court, holding the claims of the Westinghouse Company as correct and deciding that the construction used in the motor is an infringement of the Noland patent.

AMERICAN LOCOMOTIVE COMPANY.—This company during the past few months has received a number of large orders for foreign shipments, especially to the far East. These aggregated in all 251 locomotives. One order of 183 locomotives, for the South Manchuria Railroad Company, is believed to be the largest order ever received by a locomotive company in this country for foreign shipment. This order is made up of six different types, all of which will be of American design throughout. Another order recently received was for three Mallet compound locomotives for the Central Railroad of Brazil, which will have a total weight, locomotive and tender, of 303,000 lbs.

CONSULTING TECHNICAL ADVERTISING COMPANY.—A company has recently been established in Chicago, which is devoted to a consulting practice in engineering and general technical advertising. It is prepared to render careful and expert service in advising the choice of mediums, preparation of advertising copy, changing of copy, and all other phases of dignified publicity. This is known as the Vredenburg Company, with offices at 1332 Monadnock Block. Its manager, Mr. Clarence Vredenburg, was editor and manager of the *Engineering World* from its inception until its recent sale, and has many friends in the technical field.

ANNUAL REPORT OF THE AMERICAN LOCOMOTIVE COMPANY.—The sixth annual report of the above company, issued on June 30, shows the gross earnings for the year to be $49,515,486.33, an increase of nearly seven million dollars. The net earnings were $6,771,105, an increase of $308,599. The net credit to profit and loss after paying 7 per cent. dividends on the preferred capital stock of $25,000,000 and 5 per cent. on the common stock of $25,000,000 was $1,358,206.93, an increase of $241,578. During the year the structural steel department established at Montreal was sold to the Structural Steel Co., Limited. The Montreal plant will hereafter devote its attention exclusively to the manufacture of locomotives, steam shovels and rotary snow plows.

(Established 1832).

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A RATIONAL APPRENTICE SYSTEM.

New York Central Lines.

Part IV.

Abstract of the Proceedings of the First Conference of the Apprentice Instructors.

A conference of all of the apprentice instructors of the New York Central Lines was held at the Collinwood shops, September 18 and 19. Mr. C. W. Cross, superintendent of apprentices, presided while shop topics were under discussion and Mr. W. B. Russell, his assistant, while educational subjects were being considered. The drawing instructors present were, Messrs. A. L. Devine, West Albany; C. P. Wilkinson, Jackson; G. Kuch, Sr., Depew; R. M. Brown, Collinwood; Henry Gardner, McKees Rocks; F. Deyot, Jr., East Buffalo; A. W. Martin, Brightwood; C. A. Towsley, Elkhart and H. S. Rauch, Oswego. The shop instructors present were, Messrs. Frank Nelson, West Albany; C. T. Phelan, Jackson; P. P. Foller, Depew; Thomas Fleming, Collinwood; J. R. Radcliffe, McKees Rocks, and J. S. Lauby, Elkhart. Mr. F. W. Thomas, supervisor of apprentices on the Santa Fe; Mr. John Purcell, shop superintendent of the Santa Fe at Topeka; Mr. Martin Gower of the Canadian Pacific Railway, and Mr. R. V. Wright, editor of the American Engineer and Railroad Journal, were present, as invited guests. Several of the mechanical officials at Collinwood dropped in at various times and took part in the proceedings.

The conference was a great success, although it had been arranged in only a few weeks' time. The papers presented were short and to the point, and the discussions were very practical, bringing out much important information as to the various methods which had been used and had given good results at the different schools. For this reason, and because of the importance of the apprentice question at this time, and the demand for concrete information concerning the working of successful systems, we feel justified in presenting a rather complete abstract of what took place at these meetings.

Mr. Cross' Opening Address.

In opening the conference Mr. Cross spoke in part as follows:

"The foundation principle of this apprentice system is the combination of the practical and educational training of apprentices, in a manner to provide for recruiting the service with young men who have been trained in the details of the work under actual shop conditions and in the atmosphere of the shop. The higher officers, subordinate officers, foremen and workmen, as well as the apprentices, are enthusiastic in their commendation and support of it. It means that the shops will be supplied with workmen who have been trained in the theory and practice of the business and their efficiency will be correspondingly increased."

"The subject of administration is of special importance at this time. The standing of the instructor in the organization, his relation to the apprentices, to the workmen in general, and to the foreman and other local officers, is important. If this relation is right and there is a thorough support and co-operation, the results cannot fail to be satisfactory. With regard to shop practice in instructing apprentices, any set rules for the purpose would soon become obsolete on account of the frequent changes, due to improvements. The better plan, therefore, seems to be to have the instructor one who is a part of the organization, in an official position, in addition to that of instructor, thus being in possession of all information covering changes and standards. This combination will enable him to impart to the apprentice instructions in line with late approved practice, in addition to the fundamental principles of the several mechanical trades.

"The best method of handling work to increase the efficiency of individuals and of machine tools should be made a subject of frequent consultation between the instructor and the foremen. This should be done in a manner to impress the foremen with the value of the services of the instructor, in helping him to increase the output and quality of the work of his department."

Mr. Russell's Remarks.

Mr. Russell spoke of the educational part of the work as being one of the most difficult problems along educational lines, because of the ungraded classes. He called attention to the far-reaching effects of the training now being given, and asked the instructors to take a broad view of the work and to keep in mind the final results to be obtained, especially when they were apt to be discouraged. He brought out the fact that no two boys were exactly alike, that each requires a different treatment and that it is often the off-hand word, or the problem, thought of at the moment, that may make the deepest impression. The fact that the greatest flexibility must always be maintained in the methods of teaching and in the subjects taught, was emphasized, as well as the importance of covering the ground thoroughly and not attempting to rush the work. Each drawing instructor should have an assistant, or understudy, who will be in position to assume his duties temporarily, in case of emergency, or permanently, if necessary.

Entrance Examinations.

Should an Admission Examination in Arithmetic Be Given?

Mr. J. S. Lauby.—Yes! It is argued that anyone that can pass the examination is too wise to want to learn any of the trades that require hard, muscular labor, as for example, the boilermakers' trade. Facts have shown, however, that if the boy can pass the examination, he is bright enough to grasp all the opportunities that are given him to acquire knowledge, and knows that general culture will be beneficial to him in any trade or profession that he may choose to follow. Boys who are entirely devoid of ambition do not often make desirable men, even though they may develop into men of great muscular ability and rugged constitution. A man that is only a machine is seldom automatic and requires a man to operate him.

Only recently we had an applicant for machinist apprentice who knew absolutely nothing about multiplication or division Had he been taken on as an apprentice he would have had only about one-half hour training in mathematics each morning that he attended classes, two days per week, or in other words about an hour each week. While in the shop he would have had approximately 50 hours per week at his trade. He would thus have been advanced so much more rapidly at his trade than in mathematics, that we could not possibly have had him ready at the expiration of his apprenticeship to solve the problems that come to the journeyman in calculating gears for screw cutting; finding unknown dimensions for given ones; and in making the ordinary calculations required. In addition he was detected copying from the work of another applicant who was being examined at the same time, showing a disposition to deceive. Would he not deceive his foreman later on in his work, if an opportunity presented itself?

Our examination is not a hard one and we have no fixed grade that must be attained to pass, but we determine by close observation the applicant's aptness and disposition. Sometimes an applicant will show by his work that he understands the methods that should be employed, but is hasty or careless and consequently inaccurate, or that his memory is at fault and only requires a little prompting to recall similar problems of his school days. The examination therefore gives us a knowledge of his weak points and when he comes under our instruction we know just where to strengthen him. He is advised at the beginning

of the examination that anything he does not understand relating to the meaning of the questions or problems will be fully explained, but that we are not permitted to suggest any answer or method of solution.

Discussion.—The fact developed that, while at all of the schools some form of so-called entrance examination is given, it is not in reality an examination in the ordinary sense of the word. In some cases it is quite informal. The boys are not required to attain any given grade, but the way in which they answer the questions gives the instructor a clue as to their knowledge of simple arithmetic. It was generally agreed that these examinations were much less important than sizing the boy up in an informal chat. A boy who applies for admission and has had very few opportunities will in many cases make better material eventually than one who has had greater opportunities but has not taken full advantage of them, although of course the latter boy would make a much better showing in a formal entrance examination. Certain apprentices, such as boiler maker and moulder, will not require as wide a knowledge of mathematics as those in some of the other trades.

In a certain large technical school an entering class numbered 450, but four years later there were less than 200 of them graduated. Most of those who fell out found they were not fitted for the profession for which they were studying. This shows how futile entrance examinations are for weeding out material which is not desirable. In closing the discussion of this question the following quotation was read from a paper presented before the American Society of Mechanical Engineers in 1899 by Mr. Milton P. Higgins. *"Instead of entrance examinations, a careful, quiet, honest investigation into the boy's life, as to habits of work and study, as to his personal habits of order, as to how he spends his evenings, Sundays and holidays, as to his love and care of tools for mechanical work, especially as to what he has actually constructed with tools before he was 11 years of age. Are not these things a truer indication of a boy's fitness for the life of a mechanic or engineer than the one single quality of being able to pass written entrance examinations?"*

What Kind of Boys Make the Best Mechanics?

The following question was asked by Mr. Gower and a vote of the instructors was taken. "In your opinion which boys make the best mechanics: a, those with no education; b, those with a public school education; c, those with a high school education; d, those with a technical school education?" It was the unanimous opinion that boys with a public school education would make the best mechanics. Those who have a high school or technical education, after they have received a thorough shop training, if they have the right kind of stuff in them, are equipped for more important positions.

Moral Training of Apprentices.

WHAT CAN THE INSTRUCTOR DO TO DEVELOP CHARACTER IN THE APPRENTICES?

Mr. H. S. Rauch.—The instructor should first see that his own character is above reproach, then get the confidence, and with it the esteem of the apprentices. He should find out how they spend their time outside of shop hours; if some are in the habit of keeping questionable company, a friendly confidential talk will many times work wonders. The services of the Railroad Y. M. C. A. can be enlisted to good advantage in helping to mold the character of our apprentices, as it always stands ready to give a room for meetings, lectures or discussions.

Apprentice clubs will go a long way toward keeping the apprentice well employed while out of the shop. A room should be provided for the apprentices, preferably at the Y. M. C. A., where they can drop in at any time and find good reading in the shape of mechanical journals and general literature. The railroad could lend its papers with the assurance that they would be taken care of and returned after a reasonable length of time.

Instructors should try to find all the good there is in an apprentice, and should appeal to that vein of good to correct any evil tendency that may exist. If they should get into bad company and into trouble, as sometimes happens, the instructor should use all his influence to help them out, and he will then have a lever to influence them for good. He should always show them that he has their future welfare at heart, and that he expects big things of them, and they will not often disappoint him.

Discussion.—It is, of course, first necessary to gain the boy's confidence, and then to try and correct any evil influences by bringing better ones to bear upon him and talking things over with him in a quiet way. The question of cigarette smoking was

NEW YORK CENTRAL LINES APPRENTICE INSTRUCTORS' CONFERENCE.

Top row, reading from the left: J. S. Lauby; Frank Nelson; A. L. Devine; Henry Gardner; F. Deyot, Jr.; R. M. Brown and C. P. Wilkinson. Intermediate row, reading from the left: C. A. Towsley; C. T. Phalen; J. R. Radcliffe; Thomas Fleming; W. B. Russell; H. S. Rauch and Martin Gower, C. P. R. Lower row, reading from the left: G. Kuch, Sr.; A. W. Martin; P. P. Foller and C. W. Cross.

discussed. At some of the schools boys who smoke cigarettes are discharged if they will not give it up, and the general opinion seemed to be that boys who have this habit should not be enrolled as apprentices.

The moral development of the boys is exceedingly important; it will make no difference in the immediate shop output, but ten years from now it will bring results in plenty. The development of loyalty to themselves, their employers and their country—this is worth more in dollars and cents than most of us dream. What can be better for everyone concerned than an earnest, loyal corp of employees, sober and industrious, wide awake and ambitious.

The Ideal Relations Between Apprentice and Instructor.

Mr. H. S. Rauch.—The relations which should exist between the instructor and the apprentice are those which exist between close friends. The boys should be given to understand that they are welcome to come to the instructor at any time, either in the shop or outside, for all kinds of advice, not only as to their work but on any subject which may be uppermost in their minds.

Always make the apprentice feel welcome by giving him your attention and a pleasant word; get his confidence by showing him that you have confidence in him; be interested in those things he is interested in, both in the shop work or in the pursuit of pleasure. If a boy is interested in baseball, talk baseball to him; if boating, fishing or horses, talk these with him at the proper time, and you will soon have his entire confidence. Under all circumstances show him that you are his friend, champion his cause, if it be a worthy one; if not, show him where he is wrong. Never let an opportunity go by to help him, to show him that his interests are your interests; never fail to show your approval of his laudable achievements; give praise where praise is due, and if it becomes necessary to reprove him, do it privately and in such a manner that it will leave no sting. Never promise things you are not sure you can do; treat the apprentice as though he was a man; boys like to be taken for men. Consult with the boys on any matter in hand; get their opinion as though they were men; in many cases it will be of more value than you think, and even though it is valueless, the next time it will be better. Thus show them that you have confidence in their ability and they will strive not to disappoint you.

A foreman wanted sketches and a tracing of a conductor's box; he was in a hurry; the shop draftsman was crowded with work and could not make them, but finally induced the foreman to let a second-year carpenter apprentice make a try at the job; he thought he couldn't do it; his instructor told him he knew he could; he did, and made a good job of it, and the result was 100 per cent. increase in the interest of the apprentice. Instill in the minds of the apprentices that we are all working for a common goal,—that of advancing our positions in life,—and that everything learned makes us just that much more valuable to the company by which we are employed.

Discussion.—This paper also brought out the question of improving the morals of the boys, and it was quite generally admitted that more could be accomplished toward correcting bad habits by having a quiet talk with them, individually, than in any other way. Concerning the matter of swearing, Mr. Purcell stated that when he found a boy using such language he usually asked him how he would like to see it in print with his name signed. This usually made such an impression upon the boy that he was more careful in the future.

Educational Work.

How to Interest Boiler Shop Apprentices.

Mr. C. P. Wilkinson.—It is well known that the boilermaker's trade is one that does not appeal to the type of boy who cares to study and read, and consequently it is necessary to take those who, as a rule, care but little for books, but who nevertheless "make good" in the shops. To interest this class, school work should be confined almost exclusively to boiler shop practice and should combine the drawing and arithmetic almost from the start. It is all right to give these boys the first twenty or thirty sheets in mechanical drawing, which are used by the other trades, but after that they should be given simple plate work in drawing, and such problem work as figuring areas and weights. Instead of car and locomotive details in drawing, familiar objects in the boiler shop should be considered, such as flange blocks, various small tools, boiler braces, stays and clamps, and later, if they are able to go ahead, the more complicated work of laying out.

As soon as a boy shows that he is worthy of advancement and takes an interest in his work, have him, instead of putting in his whole time in the drawing class, go to the shop and assist in laying out work or doing it himself. This will encourage him in his studies. In order to hold the interest of boiler shop apprentices, the work cannot be too simple at the start. If it is too hard they easily become disheartened.

Discussion.—At the Jackson shops the boys, after they have done a certain amount of drawing work, are occasionally turned over to the boiler shop foreman and do actual laying out under the direction of the layer out. While laying out work to full size on wrapping paper in the drawing room is of value, it does not appeal to the boys the way the actual work does, and this is especially true if, after they have laid a sheet out, they are required to follow it up and finish it. Where laying out work of this kind is done the boys work continuously at the job until it has been completed and the time is credited to their school work.

The suggestion was made that ¼ size wooden models could be made of the different parts of the boiler; the apprentice could then lay the different sheets out on paper, and after cutting them to shape, place them about the model to see that they fitted properly.

The general opinion seemed to be that it would be advisable to start the boys upon boiler shop subjects, in connection with their drawing course, as soon as possible, rather than to have them keep on exercises which had been arranged for the machine shop apprentices.

Type of Problems that Appeal to the Boys.

Mr. C. P. Wilkinson.—With the many different dispositions and influences to contend with, it is out of the question to have any fixed rule to fit all cases, yet it would seem that much can be accomplished if we fully realize the things a boy should know and teach him these in as simple a way as possible, without attempting to drive him.

Illustrations should be used in connection with the problems, as they give the boys a better understanding of the subject. Use sketches or diagrams with every problem possible and boil all subjects down to the limit of simplicity and directness. The examples should not necessarily be confined to railroad work, but should include anything about the home or outside that is familiar; the result will indirectly benefit the railroad. Problems in the nature of the following should be used: Find the number of cubic feet in a coal bin shown in a sketch and the tons of coal it will hold. Find the gallons, or barrels, contained in a cistern shown in a picture. Find the cost of sidewalk per square foot. Find the cost of carpet per room plan. A few problems of each kind would be beneficial to the majority of apprentices. From the shop, problems in springs, when a sketch is given to show the method of calculating; or to find the weight and the square inches of wearing surface of an axle shown on a sketch. Even where it is impossible to make any headway with a boy in the drawing room, instruction along these lines has produced good results.

The same course should be followed with all apprentices, as has been outlined for the boiler shop boys; that is, when they have drawings to make where laying out is involved, they should spend a part of the school time on this work in the shop.

Discussion.—The instructors strongly advocated the use of as many sketches or illustrations, as possible, in connection with the problem sheets. It not only makes the meaning of the problems plainer, but serves to increase the interest which the boys take in this work.

Problems, Should they Be Compulsory?

The topic was opened by Mr. Henry Gardner, who presented a plain statement of the difficulties encountered in keeping the

boys interested in this work. Problem work should be made compulsory. When a boy enrolls as an apprentice he is given to understand that there is a certain amount of study which must be done outside of working hours. The company pays him for the two hours that he attends school two mornings in the week and it is only fair that he should be willing to devote some of his own time to educational work. The surroundings of some of the boys at their boarding places is not very favorable for study, but a difficulty of this kind can usually be overcome by a boy with any ambition. Many of the boys spend their noon hour on problems.

A certain part of the school time may be advantageously given over to this work, but this should be more along the line of blackboard exercises for the purpose of reviewing the work, and seeing that the boys understand the principles which they have learned. The ambitious boy does not ordinarily need any coaxing or incentive, but the greater number of the boys require careful looking after as regards the problem work. The conference fixed upon a minimum number of problems which must be done correctly by each boy every month; this minimum was made low enough so that there can be no reasonable excuse for any boy not accomplishing it, and if he cannot do so he is hardly a fit subject for apprentice training. While this minimum was established, most of the boys are capable of doing much more; the actual number required of each one depends on his ability and is to be determined by the instructor. It is possible to interest some of the slower boys by substituting problems which will attract and interest them more than the ones in the regular course; this is left to the judgment of the instructor. The question would be a considerably easier one to solve if the apprentice school could be graded, but it is impossible to do this.

How to Secure the Best Results in Blackboard Problem Work.

Mr. A. L. Devine.—The necessity for introducing blackboard work in connection with the problems was seen soon after the inauguration of the apprentice school at the West Albany shops. The reasons were as follows:

1. The fact that no examination in arithmetic was given had resulted in the admission of a number of boys deficient in addition and subtraction. Several instances had been found where a number of apprentices lived in the same house (six in one case) and where one of the number had worked the problems for the others. In many cases friends or relatives were working an undue proportion of the home work, and the boy himself but a small part of it. The blackboard work enabled the instructor to locate these conditions and find whether the boys really understood the work they were doing.

2. The gain derived by the apprentice in increased confidence by working problems before the others.

3. The advantage of this form of work as a review and as an opportunity for the instructor to correct faults and get familiar with the boys' real ability. This would also offer an opportunity to relieve the instructor's work by the use of advanced boys to check the slower ones.

The following methods were tried: The entire class was sent to the board, and simple arithmetic problems were given out verbally, the same problems to the entire class or to different groups. This did not work well because of the tendency to copy, and the time required to give out the problems and to check results. The boys were next given problems from the PA series, pasted on card board of convenient size. This was open to the same objections as the previous experiment. Finally each apprentice was given five examples in simple addition without any wording. They were on a blue print pasted on a small card. The first example was quite simple, and the others harder so that the five would require about an hour for solution by the average boy. There were five different sets of examples, but they looked so much alike that the difference was hardly noticeable. The instructor had the answers in advance and arranged the assignment so that adjacent boys did not have the same problems. This scheme works well, causes no confusion and requires but little of the instructor's time.

The following recommendations are based on our experience at the West Albany shops.

1. That an entrance examination in arithmetic be given outside of class hours, to consist of one problem each in addition, subtraction, multiplication, division, fractions and decimals.

2. That sets of problems in groups of five be prepared for use on the blackboard, similar to those described, covering simple addition, subtraction, multiplication, division, fractions, decimals, areas, squares and cubes, and other subjects.

3. That if possible the entire class be sent to the board at the same time, at least once in two weeks, and that each boy be required to do the assigned problems correctly before he is allowed to resume his drawing.

The Type of Drawing Required for Car Shop Apprentices.

Mr. F. Deyot, Jr.—Experience has shown that distinctively locomotive drawing is not suitable for car shop apprentices and cannot be used to advantage. The first part of a drawing course for car apprentices will of necessity be somewhat similar to that for those in the locomotive department; the subjects, however, should be, as far as possible, parts of cars and familiar machines. Simpler details of the various types of freight cars can then be introduced. Starting first with the trucks, the details can be drawn and then an assembled drawing of the truck may be made. The draft gear can then be considered in the same way. Then should follow the floor plans, roof and other parts of freight cars, thus giving the apprentices who do not work directly on cars, a thorough understanding of the construction and the location of the different parts of wooden freight equipment, at the same time making them familiar with the names of the parts and the material used. Passenger car drawing should follow, and after this the engineering equipment, such as track flangers, road bed spreaders, derricks and snow plows, a class of work involving more or less knowledge of machinery.

Grading Classes.

It is practically impossible to grade them without interfering with the shop work, although it would be desirable to do so, if possible. There are, however, some advantages in being able to divide the poorer boys among the different classes, as it enables the instructor to give them more individual attention. Even where it is possible to start with the classes graded, experience has shown that the boys pull apart quite rapidly.

Separate Marks in Drawing and Problems.

Up to this time it has been the practice, at least in regard to the reports which were forwarded to headquarters, to use one mark only for the educational work. It was unanimously decided that better results could be accomplished by having two separate marks.

Should the Class Room and Shop Drafting Room Be Separated?

It was the general opinion that the school room should be separated from the shop draftsman's room, but adjacent to it, so that the drawing room records would be convenient for reference.

Drafting Room Experience.

The question came up as to whether the experience in the drafting room, which is given in some of the shops in connection with the apprentice training, was detrimental, in that it unsettled the boys for going back to the actual shop work. It was the opinion that this might be so with certain kinds of boys who had a leaning toward drafting room work but that the boy who remained in the shop would, in the long run, be better off. It was shown that only a small percentage of the boys are given the 60 or 90 day drafting room assignment and that the majority of these, if left to choose, prefer to return to the shop.

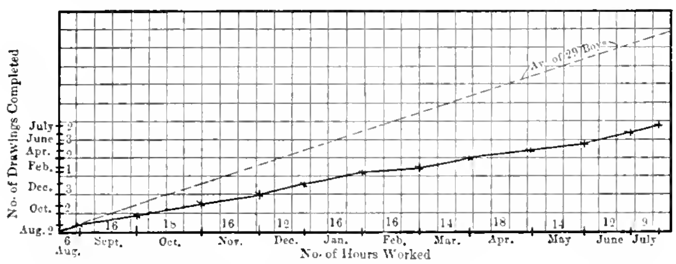
Time of Holding Classes.

There seems to be no question but that the first two hours in the morning are the most suitable for this work; other times have been tried at some of the shops, previous to the establish-

ment of the present system, but were not found to be as satisfactory. The boys' minds are clearer and they can work to better advantage in the morning. At other times in the day there is more or less running work to be finished from which the boys can often not be spared without seriously interfering with the output. From the standpoint of shop output the time of meeting would make little difference, except in cases of this kind.

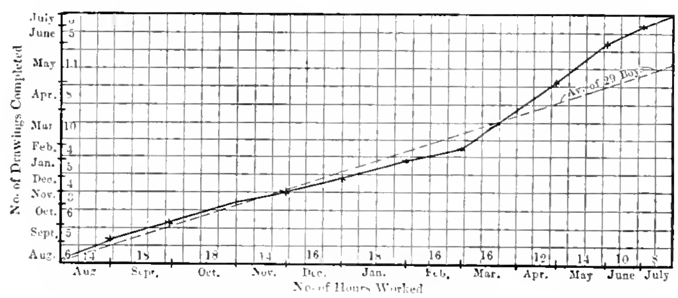
EFFICIENCY DIAGRAMS.

Mr. Henry Gardner.—In the accompanying diagrams, an attempt has been made to show graphically the work performed in mechanical drawing for the year ending August 1, 1907. The horizontal spaces each represent one hour of actual time worked, each vertical space a standard drawing plate completed. The total hours worked and the corresponding total plates completed each month are shown. The number of hours actually worked per plate was not used, as such a degree of accuracy would not be of sufficient importance to justify the amount of time and labor involved. By plotting this data we get points at the end of each month, which, when connected form the irregular line or "curve" of progress.



Total hours worked	167
Total drawings completed	29
No. drawings per month	2.6
No. hours per drawing	5.7
Mark for speed	35%
Mark for quality	55%
Efficiency	50%

MECHANICAL DRAWING EFFICIENCY DIAGRAM FOR A POOR APPRENTICE.



Total hours worked.............	174
Total drawings completed	70
No. drawings per month	5.8
No. hours per drawing	2.5
Mark for speed	80%
Mark for quality	85%
Efficiency	83%

THIS BOY "WAKED UP" ABOUT MARCH FIRST.

In order to form a satisfactory basis of comparison, averages of twenty-nine representative boys were taken which, when plotted, produced the straight broken line as shown on the diagrams. This line is only approximately correct; the actual line would be a curve obtained by plotting the mean of the twenty-nine curves superimposed. The straight line is valuable for comparison since each curve is referred to it, thus making all deductions relative and proportionate. The boys' progress from month to month is clearly shown.

No account was taken of the fact that some plates are more difficult than others and require more time and thought; such a degree of accuracy was not of sufficient value to warrant the additional labor. The plates do not vary in extreme cases more than two hours in the time required to complete them, and a large number are practically of equal weight in this respect.

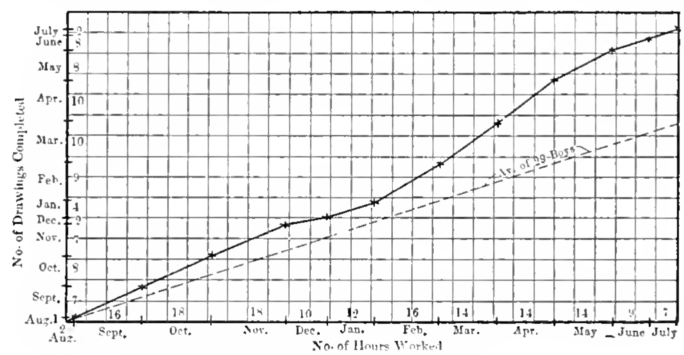
A similar diagram for the work in arithmetic could be plotted and would be equally useful and instructive. It would be more difficult, however, to determine the actual time worked since the arithmetic is done outside of the class room.

The effect of these diagrams has been to stimulate the work to a considerable extent, such that care must be exercised to keep the quality up and to discourage racing for a record. The boys are greatly interested in their "curves" and are trying to raise them higher each month.

Discussion.—It was suggested that good results could be obtained by encouraging the boys to keep their own curves or by making it part of the class work. They would thus become familiar with plotting graphical records, which are coming into more and more general use on our railroads. As regards a curve for problems, the time actually required to work them would be of less importance than the number of problems turned in, correctly worked out, at regular intervals of time.

DISCIPLINE IN THE SCHOOL ROOM.

The drawing instructor's authority, as to discipline in the school, should be absolute and thoroughly understood by all concerned. There are instances where much may be accomplished in handling a boy, who is difficult to bring into line, by having a private understanding with the shop superintendent, or master mechanic, to call the boy in and give him a talking to, with the full understanding that the instructor is in complete charge of the boy. When it comes to a show-down the recommendations of the instructor should be the ruling decision.



Total hours worked	150
Total drawings completed	71
No. drawings per month	5.9
No. hours per drawing	2.1
Mark for speed	95%
Mark for quality	90%
Efficiency	93%

EFFICIENCY DIAGRAM FOR ONE OF THE BEST BOYS.

The instructor, in order to maintain the dignity of his position, should not send the boys to the superintendent of shops for discipline, unless he is prepared to recommend them for dismissal. In speaking of this matter Mr. Purcell of the Santa Fe stated that in starting their new apprentice system he had made the ruling that the instructors were supreme in the matter of discipline in the school room, and that if the instructor sent a boy to the office for his time, no matter how slight the offense, he could not get back into the service except through the instructor. While it is possible for the instructor to handle most cases of insubordination by persuasive methods, there are times when harsh methods must be taken, and promptly.

SHOULD ADVANCED BOYS GIVE TALKS ON SIMPLE SUBJECTS?

The general opinion was that it would be a good scheme to have some of the more advanced students present short informal talks on simple topics. This would not only be of great assistance to them, but would add to the interest to the class work.

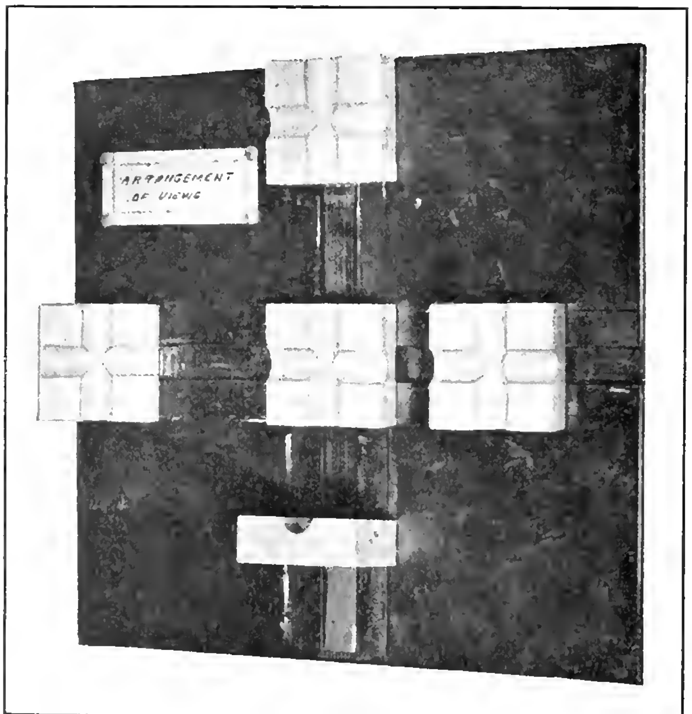
IS THE PRACTICE OF USING ADVANCED STUDENTS TO HELP SLOW ONES ADVISABLE?

Mr. J. S. Lauby.—Yes! We practice it at Elkhart and find it gives the assistant an excellent opportunity for review, and at the same time creates in the one assisted a desire to attain such an efficiency that he too can occupy the position, or else creates

a sense of shame, that his fellow student is better qualified than he is. Whichever view he takes, if he has any spirit at all, his energies are aroused and it is bound to work to his advantage. We do not attempt to use a pupil for an assistant in drawing unless he has had, or is taking, his three months' experience in the drafting room.

We are also careful to see that the assistant does not perform the work himself. This is an important point in all of our work. There are many cases where an apprentice is only too willing to let the instructor do the work while he stands by and looks on. This is just the reverse of what ought to take place to obtain the best results and in justice to the apprentice, he should be made to perform the operation, whether it be in the class or in the shop, the instructor advising, in the meantime, as to the best method to pursue.

It might be urged that the proper discipline cannot be maintained; that the fellowship existing between students is too close for one to pay due respect to another's authority. We experience no trouble, because apprentices are given to understand that a code of rules exists for their government, designed to promote their welfare, which must be adhered to. The advantage to the one chosen to assist, is an important factor in favor of the practice: It brings him in contact with the knowledge of others; broadens his views of culture in general and prepares him to meet men in a way he could not without this opportunity.



HINGED MODEL TO ILLUSTRATE ARRANGEMENT OF VIEWS ON A DRAWING.

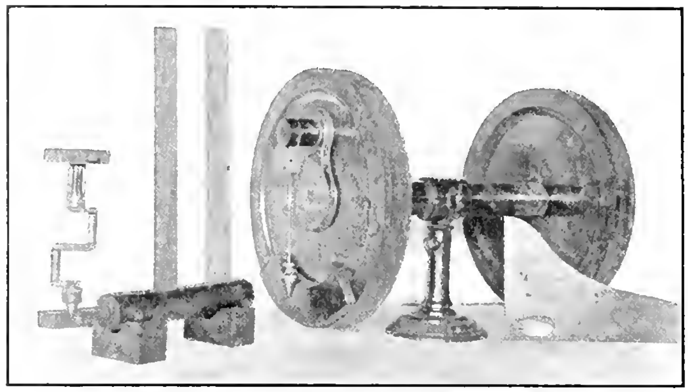
Discussion.—The general opinion was that this is a good idea. Most of the schools are using advance apprentices to assist in breaking in new boys in class work and to help the slower ones with their work. This has been carried to such an extent that while the instructors were attending the conference six out of the nine schools were in operation under the direction of the more advanced apprentices.

THE USE OF MODELS TO ILLUSTRATE SHOP PRACTICE.

Mr. C. T. Phalen.—We have constructed a model of a pair of driving wheels, with removable crank pins; also a small plumb square made of wood and wooden straight edges to match. (See illustration.) We find this very valuable for instructing the apprentices during school hours, 3 or 4 at a time, in the methods of quartering. The wheels are 12 in. in diameter and 2 in. thick; the axle is 2 in. in diameter and 14 in. in length. This is mounted on a small pedestal for convenience in handling.

We also have a small wooden axle and wooden V-blocks for use in showing the boys how to lay out keyways. The crank axle shown in the illustration is used in instructing them as to how to finish a piece of this kind in the machine shop.

Discussion.—Each school is now provided with a small vertical engine for use in connection with the study of valve setting. The fact was emphasized that, while at first the experimental work on valve setting in the class room appears a little foreign to setting



SHOP PRACTICE MODELS AT JACKSON.

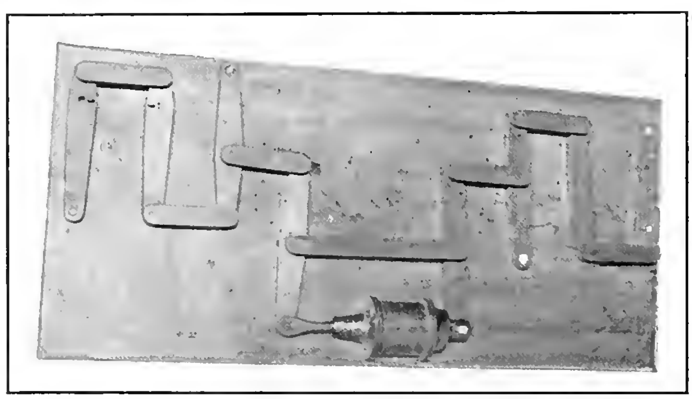
locomotive valves in the shop, it is really closely allied with it and important in making a boy thoroughly familiar with the principles of the slide valve and with parts of the mechanism, which because of the construction of the locomotive valve, cannot be open to inspection. One school is figuring on setting up, under cover, a pair of driving wheels, cylinders, and the valve motion taken from one of the old engines which is about to be scrapped. Most of the schools have a small old type engine lathe installed for instruction purposes. All the schools will, in the near future, be furnished with models of the Walschaert valve gear.

USE OF A HINGED MODEL TO ILLUSTRATE ARRANGEMENT OF VIEWS ON A DRAWING.

Mr. G. Kuch, Sr.—Where the drawing classes are large the hinged model, shown in the illustration, may be used to advantage for illustrating the arrangement of the views on a drawing. The central block is stationary, the other four are hinged on the sides toward the central block, to pieces which slide in the slots. The plan view of the object is first drawn corresponding to the central block. To find the proper relation of the side elevation the object is placed in position for a plan view on one of the side blocks, depending on which side elevation is desired, the block is then turned up; in the same way the top or bottom elevations may be properly located.

BENEFITS FROM THE CLASS WORK.

Mr. Henry Gardner.—The classroom instruction of apprentices has not been in operation long enough to show a large number of specific instances of benefit at the McKees Rocks shops. The following boys have done high grade machinist work with a skill



MODEL AT McKEES ROCKS TO ILLUSTRATE WORKING OF FOUNDATION BRAKE GEAR.

and accuracy that could not be done by an ordinary boy, without training in mechanical drawing and arithmetic:

J. H. Dwyer, age 27, began apprenticeship in 1905. In May, 1906, he

made from blue print, sketches for a template of the frame tongues on a consolidation locomotive. The template was made and sent to the smith shop and the forgings made from it. The work was correct. He has also set valves unassisted.

F. E. Cooper, age 25, began apprenticeship in 1904. In 1907 he laid off accurately four reverse shafts for some new locomotives, working unassisted from the blue print.

H. Berg, age 25 years, began apprenticeship in 1904. He has set valves on locomotives and has put up shoes and wedges unassisted. He has, by reason of personal fitness and excellence in drawing and arithmetic, served as assistant drawing instructor of apprentices and assisted with the evening classes. He is now employed as draftsman in the main drawing room, doing regular draftsman's work with entire satisfaction.

W. Bollinger, age 18, began his apprenticeship on Jan. 1, 1907. In July he bored six eccentric straps to blue print without assistance, having served only six months apprenticeship.

J. Barr, age 20, began his apprenticeship in 1905. In July, 1907, he laid off six rocker arms from blue print and finished them in the lathe. He also laid off 12 pit jacks from blue print, including I beams, stands, angles and rollers. He assembled these parts when finished without assistance.

S. Langhurst, age 20, began apprenticeship in 1905. In 1907 he laid off a set of ten rocker arms from blue print. The work was done accurately and without assistance.

In cases of locomotive and car tests apprentice boys are always chosen to work in conjunction with the drafting room force. In the case of some air brake tests conducted by Mr. W. P. Richardson, mechanical engineer, in 1905, Apprentices Cooper and Dwyer gave good satisfaction as assistants, doing work usually required of trained draftsmen. From the results thus far obtained, it is quite evident that by the end of another year, a large number of definite cases of important and high grade work done by apprentices can be cited. By that time the opportunities for the boys to show what they can do will have increased, as well as the confidence of the foremen in the boys, and they will then be called upon to take more responsibility and to do more advanced work.

Many cases of apprentice boys doing work from blue prints or sketches, and without instruction, could be stated and are of daily occurrence, but this is expected and is so certainly the result of the class room training that it is not necessary to enlarge upon it. Such beneficial results as increased ability, accuracy, responsibility, manliness and ambition are always noticeable.

Discussion.—The other instructors all presented similar reports. To prevent repetition brief abstracts only have been selected from these:

Mr. H. S. Rauch.—I asked all of our foremen this question: "Do you find any difference in the apprentices with the present system of training compared to the old system?" They all agreed that there was a great difference in favor of the present system, giving the following reasons: The apprentice, a short time after entering the service, is able to work from drawings without any help; formerly a lot of time and patience were taken to explain what was wanted and usually it wound up by having a mechanic, either watch over the boy closely, or do the work himself. The boys have better judgment, make less mistakes and consequently spoil less work. A better class of boys are applying for positions as apprentices. The boys are utilized to make sketches where before it was necessary for the foreman to do this. If any additional assistance is required in the drawing room force it is at hand. One of our advanced apprentices assists me with the school work and during my absence has full charge of the classes, maintaining good discipline. This apprentice, Mr. W. F. Black, is in his third year.

(Editor's note: A shop instructor has not yet been appointed at Oswego so that the improved results there are practically directly due to the school work.)

Mr. G. Kuch, Sr.—Several of our apprentices have advanced in their school work to a point where, if the shop draftsman requires an assistant in the drawing room, they can do the work satisfactorily. A number of the most important machines are being operated by apprentices of only two or three years' training. Several of the apprentices are used for laying out work from blue prints with excellent results.

Mr. Thos. Fleming.—When a machinist lays off and the foreman comes to the instructor and asks him for an apprentice, it does not matter what the job is, it is up to the instructor to see that the apprentice does it in a reasonable time and does it right. Our machine foreman has lots of confidence in the apprentices. There is not a day that we do not have two or more of them working on machinist's jobs. The school is a great help to them in reading drawings, a point where many machinists are very deficient.

Mr. J. S. Lauby.—An important point is the saving of time in the shop due to the apprentice training. Ordinarily a boy when put on a new job feels timid and if left to his own resources does not work the machine to its full capacity. With the shop instructor to prompt him this is overcome and the output is kept up to the standard. We had an apprentice running a planer alongside of a journeyman, who planed all of the driving boxes. An ordinary bent tool was used to dovetail a groove in each flange so that the brass liners might be cast on the boxes. The journeyman used a right hand tool for one side and then stopped the machine and changed to a left hand tool for the other side. It occurred to the apprentice that one tool could be used for both operations and he drew up a design for it. While the tool he designed proved a failure, yet the idea was ultimately worked out and effected a considerable saving of time on this operation.

Mr. C. P. Wilkinson.—Many instances may be noted where the company is receiving direct benefit; one of the foremen was taken ill and all of the laying out portion of his work was handled by an apprentice. We have apprentices on vise work, who are doing first-class work on jobs they never heard of before. One foreman when asked about the system remarked that it was a fine thing to have boys at hand who could pick up ordinary work and go ahead with it without instructions. Another point is that the boys are familiar with the names of everything used and know what they are looking for when they are sent on an errand. This was not true formerly. We now have boys running boring mills and planers, where formerly it was thought that this work could not be done by them.

The Shop Instructor.

The Shop Instructor and the Foreman.

This topic was opened by Mr. J. R. Radcliffe. The foreman and shop instructor should keep in close touch and co-operate with one another. The instructor is responsible for seeing that the boys receive the necessary instructions in their trade. He should consult with the foreman as to the shifting of the boys from one class of work to another. Such an arrangement relieves the foreman of a large amount of detail work, which he ordinarily does not have time enough to give proper attention to, because of his many other duties.

The Shop Superintendent and the Shop Instructor.

Mr. J. S. Lauby.—The ideal relation should be one of closest confidence and mutual understanding. The instructor should be given just enough preference by both the superintendent and the master mechanic to establish his position in the minds of the other employees—foremen, journeymen and apprentices—as being one that is approved by the management and will be supported by it. The apprentice has more confidence in himself if he feels that he has the support of someone that is better qualified than he is, and because of that feeling he can render more efficient service. It is the same with the instructor. If he feels that he is executing the wishes and ideas of the superintendent, he will be quite likely to use extreme caution before promulgating anything out of the ordinary. The instructor should show by conservative judgment that he is deserving of this position in the superintendent's esteem; his conduct, deportment and judgment should be such that when he reports to the superintendent, either in complaint or compliment, the superintendent may feel that the report merits consideration and that he would be justified in approving it.

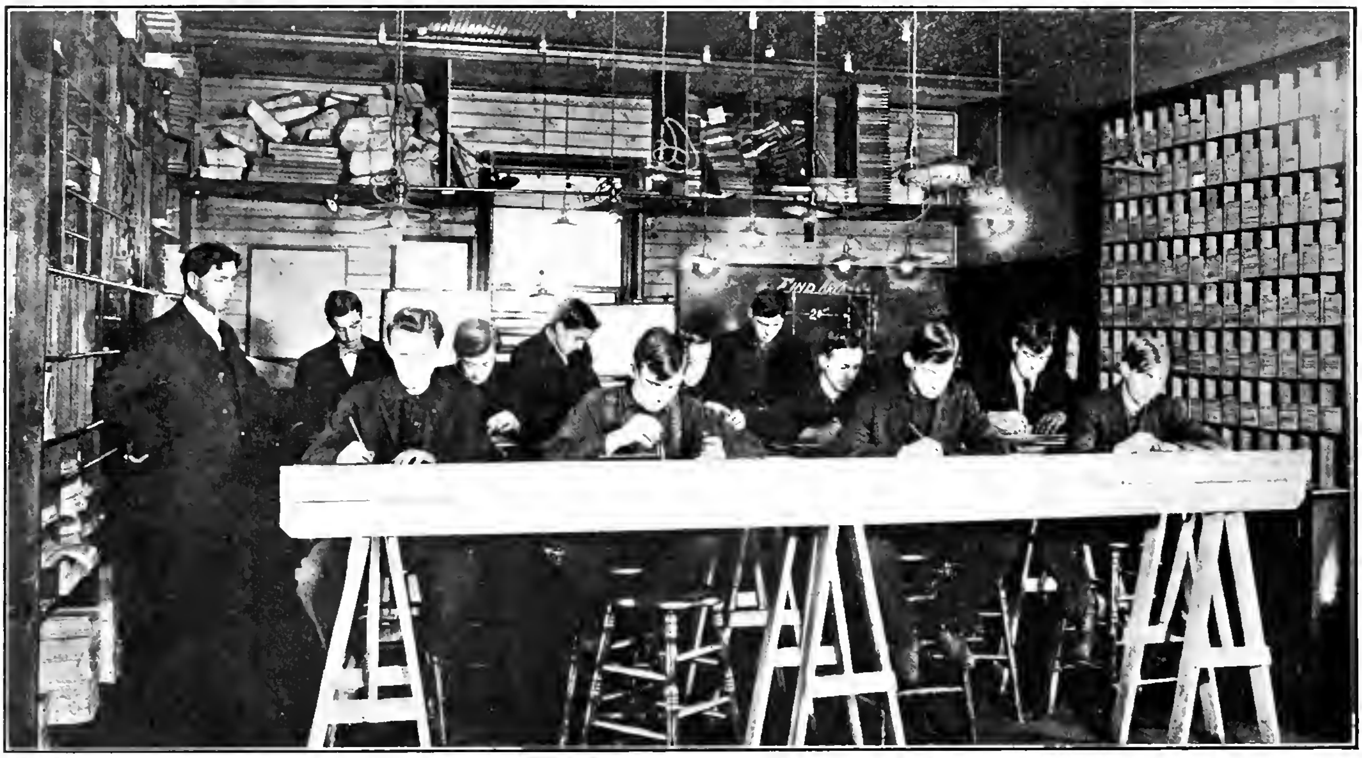
If this relation exists, many of the petty annoyances that arise from time to time may be avoided by action of the instructor, and the time of the superintendent can be devoted to more serious matters. As the instructor's field covers practically the entire plant he has opportunities for observing, greater than those of any other individual, and his knowledge should be freely imparted on any matter relating to the management's interest.

The instructor should report and be accountable directly to the shop superintendent. This does not infer by any means that he

is to hold himself aloof from the several foremen. On the contrary he should keep in closest touch with them, and endeavor as far as possible to make the changes of apprentices conform to their wishes. If the instructor will keep in mind that working for the interests of the superintendent is working for his own interests, and will reflect credit on him, the best possible relationship is sure to be maintained.

How Many Apprentices Can Be Handled Successfully by One Shop Instructor?

This topic was opened by Mr. Fleming. It depends entirely on local conditions. The shop instructors, of course, devote most of their time to the machine and erecting shop apprentices, as there are ordinarily only a very few apprentices in each of the other trades and the detail instruction of these is left largely to the department foreman, the shop instructor looking after them in a general way only. In a piece work shop, or where the number of machine tools is small compared with the size of the shop, and each one has to be worked to the limit of its capacity to produce the desired output, the boys must, of course, be given more attention than under other conditions. When apprentices are prorated with journeymen they require only a comparatively small amount of attention from the shop instructor.



ONE OF THE OSWEGO APPRENTICE CLASSES IN SESSION.

Shop Training.

Tools for Apprentices.

The general practice at most of the shops is for each apprentice to be furnished, when he starts to work, with a hammer, monkey wrench, and in some instances cold chisels and a center punch; they are also provided with a tool box, drawer or cupboard in which to keep them. The apprentices are expected to purchase inside and outside calipers, a machinist's scale and a rule. While it is not necessary to have a uniform practice in this respect for all of the shops, yet it is advisable that each shop should have a definite and systematic method for handling the boys at the start, as the first days in the shop usually make a very deep impression and it is desirable to get the boys started right.

Should Apprentices Be Started on the Erecting Floor or on the Machine Side?

Mr. F. Nelson.—Judging from our experience with apprentices at West Albany, and taking into consideration the surroundings and inducements offered machine hands by other manufacturing industries in that vicinity, it would seem best to start apprentices on the erecting floor. There are various grades of work, such as stripping, reaming and truck work on which new boys can be used to good advantage, and thus be made familiar with the size of reamers, and the methods of setting up and operating motors. This work should cover the first three to six months in the erecting shop, which would fit the boy to be prorated with a machinist on almost any job in that department. By this plan the company would derive an immediate benefit from the boy's work. It also keeps the boy looking forward to the time when he is to be transferred to the machine shop. When shifted to the machine shop he is familiar with the file, hammer and cold chisel and can be put on almost any bench job; he is able to lay out work and is familiar with the work that may be sent from the erecting shop for repairs.

As the machine shop is the critical point, as concerns the output, it should not be burdened with new boys. The boys started in the machine shop are much older and stronger when transferred to the erecting shop, and consequently feel that they are working at a disadvantage when helping on the erecting floor. They often show by their general conduct that they are dissatisfied and this condition prevails until they are shifted to valve setting, guide work, or shoe and wedge work.

Although there are various things in the machine shop that new boys can do and be of service to the foreman, they do not, during the first two years, grasp as fully the opportunities offered there, as they do during the third and fourth year. If the machine work comes at the end of the course the result is a better grade of mechanics. Earnest observation has led me to believe that the erecting floor is the proper place to start apprentices in order to obtain the best results and to produce the most competent men.

Discussion.—The general opinion was that the boys should be started in on the erecting side. As a rule boys who are not strong enough to do this are hardly desirable as apprentices. The general information they gain on the erecting side, as to the construction of a locomotive, makes them more valuable as machine hands.

Who Should Have Charge of Shifting the Apprentices?

Mr. Frank Nelson.—The shifting of apprentices should be en-

tirely in the hands of the shop instructor for the following reasons:

He comes in personal contact with the boys and is better qualified than the foreman to decide what job the boy is best fitted to be transferred to.

The instructor must have this authority to enable him to enforce the proper discipline.

The boys should look to the instructor for a final decision in any matter under consideration.

If the foreman be given charge of shifting he might, for what appeared to him to be good reasons, shift several in one day to new and scattered jobs. Under these conditions it would be impossible for the instructor to give each boy the necessary direction and attention.

The instructor and not the foreman is held responsible for the future welfare of the boy and the grade of mechanic he makes.

The instructor is wholly responsible for the output of the job upon which the apprentice is working.

When the foreman desires to shift a boy for any reason he should notify the instructor. On the other hand, the instructor should consult the foreman before shifting boys, and they should come to a mutual understanding in regard to the matter.

Does Class Work During Working Hours Interfere with the Shop Work?

Mr. J. R. Radcliffe.—At McKees Rocks we have 35 apprentices, who are divided into three classes; each class attends school two mornings, or four hours per week. The result is that seven to ten machines are idle for two hours each morning, or a total of from 14 to 20 hours of machine work is lost each day. The absence of the boys from the machines affects the shop output, more than their absence from any other department, since the shop output is most directly dependent upon the machine shop. This difficulty can be regulated to a certain extent by taking boys from floor work and putting them on the machines during the school hours. When necessary a boy may be kept from school to do special work, allowing him to attend school with some other class when the work is finished. If judgment is used in changing boys and holding them to their work, when necessary, the bad effect on the output will be greatly reduced, but in order to accomplish this the "Ideal Relation" must exist between the shop instructor and the foreman.

Discussion.—The situation may be relieved to a certain extent by having the shop instructor advise the foreman of the names of the boys who will attend class on the following morning. A couple of the shops have what is known as a "floating gang" of apprentices, consisting of two or three members who are used specially to take the place of boys who are attending class during the first two hours. The importance of keeping the machine tools working cannot be too strongly emphasized. It is better for the company to have a file lying idle than a machine tool, which may cost anywhere from a hundred to ten thousand dollars.

The Apprentice System and Piece Work.

Mr. Frank Nelson.—Piece work is a benefit to the apprentice system. It teaches the boy to establish a systematic procedure whereby he can do the most work in the shortest time. It teaches him to keep his tools in proper condition so that there will be no time lost on the job upon which he is working; it teaches him to be accurate and careful in his work, for if he is not he loses financially. It emphasizes rapidity in his method of doing work and teaches him punctuality. Every moment wasted is a distinct loss to himself.

The apprentice system is a benefit to piece work, for when a boy is first started on a job the instructor's aim is to teach him to do it as quickly as possible, so that he can work piece work, which he is anxious to do, since it increases his day's wages. Piece work induces a better grade of boys to learn the trades, for they feel that in this way they have an opportunity to get a practical education and at the same time a chance to earn sufficient wages to supply their needs while learning the trade.

Grouping Boys for Instruction on Machines.

Mr. P. P. Foller.—Viewing the matter from a practical standpoint, I feel quite confident that very little good would result from a demonstration of machine practice to groups. As a rule, the boys are those who have had but little practical experience in operating machines, consequently such demonstrations would approximate "book training" and would be of little practical assistance.

I find no better way of educating a boy for machine work than that of the old-time practice, *i. e.*, to start each boy on the simplest line of machine work and if he shows an adaptability to become a machine hand then advance him, step by step, until he has reached the highest grade of machine work.

Oiling and Care of Machine Tools.

Mr. C. T. Phelan.—The necessity of taking proper care of their machines should be impressed upon the minds of the apprentices through the instructors. This should be done at the very start and should be religiously followed up.

Detaching a Boy from his Regular Work to Assist on an Especially Interesting Job.

Mr. C. T. Phelan.—This is a good scheme, although it is not regularly practiced at Jackson. In doing it care should be taken not to interfere with his regular work to any great extent.

Discussion.—A certain amount of such work is advisable, but it should not be overdone.

The Rate of Pay for Graduate Apprentices.

A graduate apprentice should be paid at the same rate as a journeyman who is taken in from outside. Certainly the boys who have spent four years in the shop, receiving a thorough training in different classes of work and with the advantages which they have gained from their school work, are worth at least as much as the man who is taken in from the outside. In order to keep the boys in the company's service they should be paid at the same rate.

Apprentice Auxiliaries, Etc.

Apprentice Clubs.

Mr. C. A. Towsley.—The need of an organization that would appeal to the young men of the Elkhart shops was realized by our former master mechanic, and present superintendent of apprentices, Mr. Cross, and through his efforts an organization was perfected a number of years ago; the success of the club has been very gratifying. The objects are, first, to create a feeling of fellowship and thus bind the apprentices of the different trades closer together; second, to provide for their intellectual, moral and physical welfare.

The place of meeting should be in, or adjacent to, the school room, in order that the members may have access to the school apparatus, blackboard, library, current magazines and collection of blue prints. The room should be made to look as inviting as possible, with pictures on the walls and the books and periodicals placed conveniently.

The Elkhart Club aimed to ultimately raise the tone of the workmen and to develop from among the boys earnest workers, who, perhaps without bright and helpful associations, would have been content to remain in the narrow confines of the laggard. This desire has been realized to a certain extent and a number of its members have broadened out and are taking advantage of the opportunities offered. Several have had hidden talent cultivated and are now holding jobs that will eventually lead to positions of importance. This is a possibility in every club and the officers should see that the efforts of the careful, painstaking worker are recognized and that he is given all possible opportunity to broaden and develop. The lectures, papers and discussions should embrace subjects which tend to awaken the interest of the listless ones and to stimulate interest already awakened. Practical talks by different foremen, on their special line of work, bring out valuable points for the apprentice and broaden the ideas of those in other departments. A forceful method of illustrating different operations is the use of the reflection lantern, by means of which photographs, blue prints, and magazine illustrations may be projected upon the screen.

The regular meetings of the club will give the members a

knowledge of parliamentary practice. They will also develop a feeling of independence from the fact that the meeting is their own and is officered and managed by their own members. Subjects may be assigned to members to be presented in the form of a paper. This can be followed by a debate in which all members should be urged to take part.

Another point that might be of benefit in maintaining a spirit of independence would be a small assessment, quarterly or semi-annually, which would also provide for any emergency which might arise and would avoid the necessity for levying a large special assessment. The library consisting of reference books and periodicals should be regarded as an essential part of the school and club. The boys should be urged to make use of the room, outside of shop hours, and especially during the noon hour, when the instructor is on duty.

Discussion.—The idea of apprentice clubs was received very favorably, but the problem of getting the boys interested in such a club at a shop where most of them live a long distance from it, is a rather serious one and means that the inducements must be made especially attractive in order to get anu keep the boys interested in it.

The Elkhart club expects during the coming winter to have a series of talks which will cover the complete building of a locomotive. These meetings will be very informal and the boys will be expected to ask the speaker questions.

Each club room should be supplied with a file of such catalogs, as might be of interest to the boys, and a number of technical papers, the latter to be supplied by the railroad company.

The Value of an Apprentice Baseball Team.

Mr. R. M. Brown.—A baseball team is an important factor among the apprentices or employees of a railroad shop. The success or failure of the team hinges closely upon one thing, "organization." Any one who is at all familiar with baseball, knows how utterly helpless an individual or a team would be (no matter how quick or skilful), without the aid of the other players. Every man's success depends upon his ability to work with those around him in an organized body, each helping the other and all working and pulling in one direction toward success. Team work is what counts, whether it be in baseball or shop work, and an apprentice baseball team properly managed, and duly recognized by a sympathetic shop management, will [illegible] the efficiency of the apprentices.

A baseball team is also a means of getting the boys acquainted, not only with each other, but with the men. This is especially true [illegible] are played with the shop men or with the officers. Without in any way interfering with the proper relations between the boys and the company officers, the team can be the means of making many of the boys personally acquainted with their superiors.

Another feature of the baseball team is the advertising effect. One would be surprised at the number of boys in Cleveland, for example, who have never heard anything about the apprentice system of the New York Central Lines. One of the Collinwood apprentices, who appeared on an amateur baseball diamond, rigged out in his apprentice uniform, had to answer many questions about the team, shop and pay. As a result, a number of boys have called at the instructor's home to inquire about the apprentice trades at the Collinwood shops. The newspapers are always glad to publish the results of games played, which serves both to encourage the team and to give publicity to the apprentice movement.

A baseball team also plays a part in making a boy contented and happy to stay in the service. It is but one factor, and yet experience has shown that it is an important one, and that the organization of a team may turn a fault-finding and grumbling apprentice into one who is not only proud of his team, but also of his shop and its officers.

It is perhaps conceivable that with unwise management of a team, or with shop officers who fail to realize its value, there might be disastrous results, but happily the apprentice teams thus far have been well managed and the company officers have always stood ready to encourage, accommodate and help.

Discussion.—The Collinwood and Elkhart teams played a couple of games together, the drawing instructors accompanying the teams on the trips. This gave them an opportunity of getting better acquainted and closer to some of the boys than would have been possible otherwise. The games were played on Saturday and the members of the teams, therefore, only lost part of the day from their work. The expense of the suits and other equipment was provided by subscription. In connection with the discussion of this subject the matter of annual apprentice picnics was brought up and was favorably regarded.

THE APPRENTICES AT THE JACKSON SHOPS—MICHIGAN CENTRAL RAILROAD.

An Apprentice Button.

Discussion.—It was agreed that it would be advisable to have an apprentice button which would be furnished free to each apprentice in good standing. It was suggested that it might be a good idea to furnish this button only after the apprentice had completed a certain amount of work in the problem and drawing courses. The idea of having a graduate button was also suggested, this to be paid for by the boy.

To What Extent Should Apprentices Be Sent to Visit Other Shops?

Mr. Frank Nelson.—Boys should be sent on visits of this kind

at least once, and if possible twice during the year. The benefits may be summed up as follows:

1. The advanced ideas obtained which may aid them in their work.

2. The information derived by comparing the various methods of working with those already learned.

3. The opportunity of seeing different types of machinery and equipment.

Allowing the apprentices to make short trips to other plants has proved very successful with our boys. Although it is a year since they visited the General Electric Works and the American Locomotive Works at Schenectady, N. Y., in almost every conversation held since with one of the older boys about doing work he refers to methods in use at these plants.

Several of the boys obtained ideas which they put into use at once; one boy who was working on a boring mill changed the method of fastening the tires on the table to correspond to the methods he had seen at Schenectady. He did this without waiting for definite directions from the instructor, and soon found that he was able to gain one tire in his day's work. The impression made on the minds of the boys by observing the methods of experienced workmen prove much more lasting than when these same methods are explained ever so clearly by their instructors. It is a paying proposition to the company to allow either boys or men to visit other shops where work of a similar kind is being carried on.

The boys, after the above mentioned trips, were asked to write letters to the shop foreman as to their observations and what they had learned. These demonstrated the benefits which were gained.

How Can the Apprentices of the System Be Brought Closer Together?

Mr. A. W. Martin.—The following is a suggestion as to one way in which the apprentices at the various shops may be made known to each other. Let each drawing instructor select twelve drawing sheets and twelve problem sheets each month, four from the most advanced third of his apprentices, four from the middle third, and four from the least advanced third of his classes. These to be forwarded to the New York office and sent around to the various schools in succession and posted, say for three days at each place. As the shops are all using the same courses, the boys would be able to tell by inspecting the posted sheets the progress which was being made at the different points. This would arouse interest and rivalry. It would be advisable to have attached to each drawing sheet a slip of paper showing the trade at which the boy is working and the date when he started in the apprentice school. Thus in time the leading boys of the system would become familiar with each other's names and progress. The scheme would also keep the various instructors in closer touch with one another, as in looking over the sheets they could get an insight into methods used at other schools.

Evening Classes.

Evening Classes for Foremen and Mechanics.

Discussion.—It was decided that the methods of teaching should be about the same as for the apprentice day school classes. Important results may be obtained from these classes, and quickly, if the brighter and more ambitious men are selected from the shop. The ground to be covered would be about the same as that in the apprentice classes, the simpler parts of it being presented in the nature of a review.

This evening work should consist largely of mechanical drawing, as it has been found during the past year that the men took more interest in this than in the problem work. The number of men in the class should not exceed 15 or 20 unless the instructor has an assistant, when double that number can be handled to advantage. The evening classes should not continue after April 1.

In answering the question as to whether compensation should be paid in advance, regardless of attendance, the general opinion seemed to be that, except in a few instances, advance payment would not insure better attendance. At some of the shops the management has excused men from overtime to attend these classes. It was suggested that it would be well to block the work out for at least three months in advance.

Evening Classes for the Instruction of Mechanics in Shop Practice.

This is desirable and would probably be more successful if organized in the form of a club. Excellent facilities for demonstration may be found in connection with the actual equipment in a railroad shop which, in addition to a reflection lantern, could be used to splendid advantage for this purpose.

Abstract of Mr. Gower's Talk.

During the past two days I have come face to face with what I consider the solution of the apprenticeship question. It is one of the most important questions of the day, and when dealing with it you are undoubtedly paving the way towards a satisfactory settlement of the labor problem.

I believe yours is the only company in the United States, and probably in Europe, which has dealt with this apprenticeship problem upon sound and business-like lines, and your work is bound to bear good fruit in the immediate future.

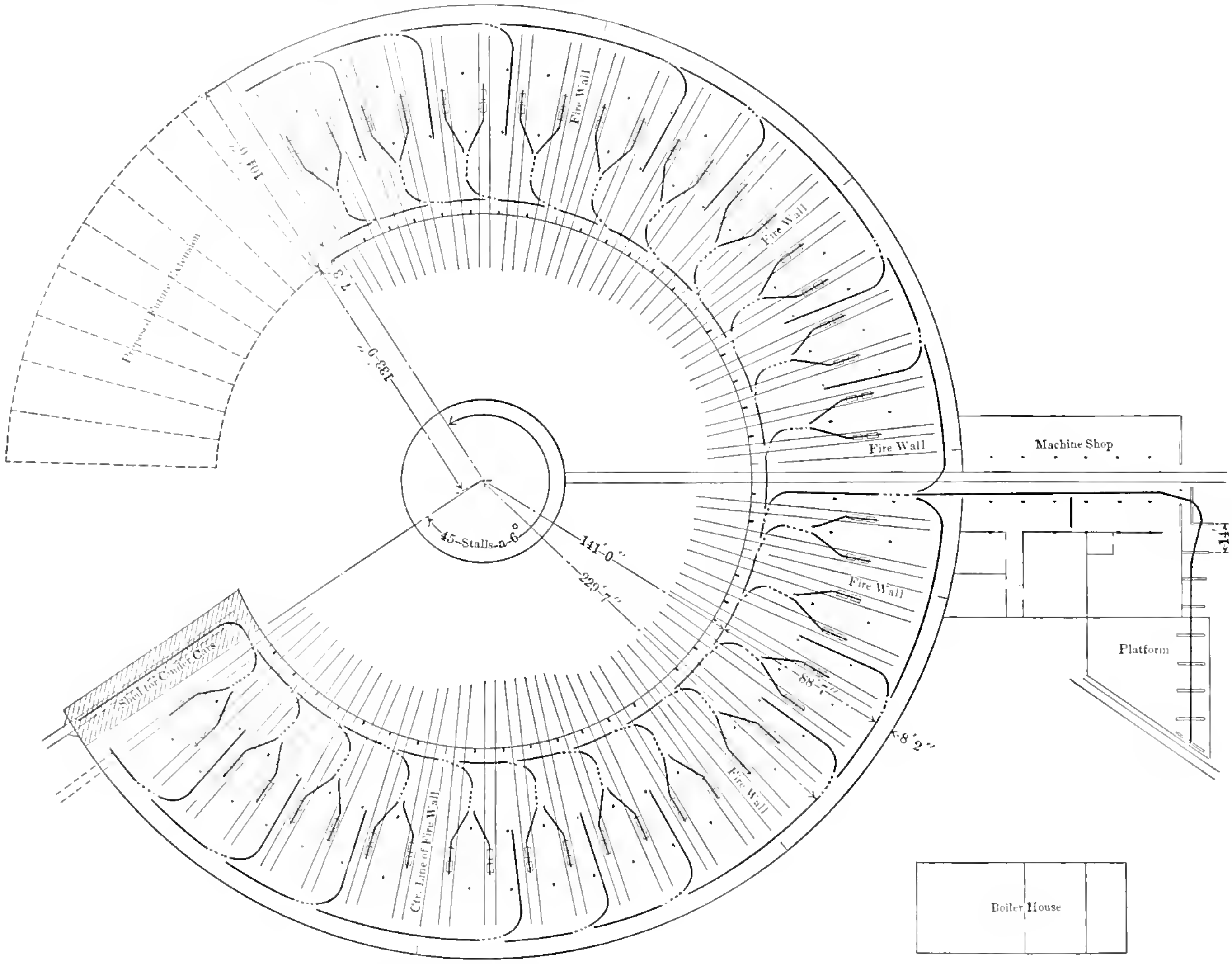
I have had many opportunities for studying the apprenticeship problem in Europe, but though several of the great European railroads and industrial firms are equipped with schools, they apparently, have not yet succeeded to the extent that the New York Central has. In my opinion the fault lies in people failing to differentiate between work taught in a concrete form and work taught in the abstract. This apprenticeship question may be looked at from two points—the educational side and the moral side. A great deal of stress is being laid on the educational side, but to my mind the most important factor is the moral training, which it is essential our boys should receive, for as we now train the boys so will our men be in the future, therefore it is essential that every care should be taken to train them to become honest, straightforward, well disciplined and self-respecting men who will be conversant with shop organization and realize that foremen are appointed by employers, not for the purpose of standing over them to see that they do their work, but to allot and give out the work required by their employers.

The word "independence" is frequently on the lips of all Americans, but independence and education go hand in hand, for the man who is trained and thoroughly master of his work can rightly claim independence and freedom, but the untrained man has to depend upon others to assist him.

It is primarily essential that a boy should be taught to think, but not merely to think, but to think in measurable quantities, and if you are able to instill into a boy's mind the principles underlying his trade you will find that he will quickly learn the details, as his mind will be trained.

As your object is to train skilled mechanics it is necessary for the instruction to be gradual, advancing by easy stages—you cannot go too slow. The men and boys who aspire to higher posts will take care of themselves. Arrange the work to meet the needs of the most backward of your boys. Your aim is to train skilled and competent workmen and not walking calculators or chief draughtsmen.

The ideal method for teaching working men is to place the actual piece of material before them and not allow them to study anything in the abstract. This method I am pleased to see you are establishing in all your schools. The machinist when learning mechanical drawing should have the actual machine or engine part before him. Let him make a rough working sketch, check his own measurements and then make a rough pencil drawing of two or more views, inserting the necessary dimensions. Instruction papers containing calculations and particulars about that piece of mechanism should be given to him when he is making his drawing. This method is preferable to the blue print system of teaching and is more likely to bring good results. Let your instruction be as practical as possible, and I cannot sufficiently emphasize upon you the necessity for all such instruction to be slow and thorough, and if so it will surely be beneficial



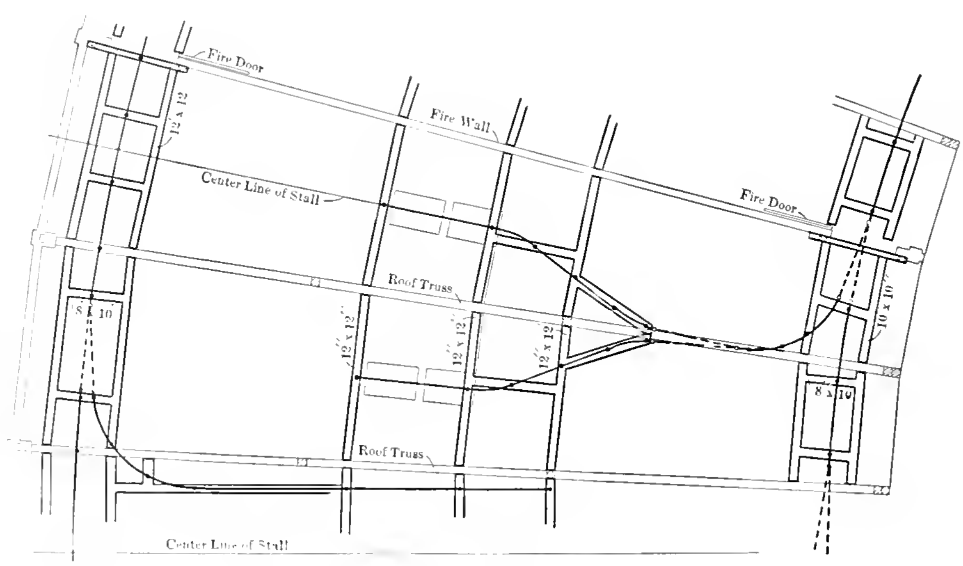
PLAN OF DILWORTH, MINN., ROUNDHOUSE—NORTHERN PACIFIC RAILWAY.

AN IMPORTANT DEVELOPMENT IN ROUNDHOUSE DESIGN AND OPERATION.

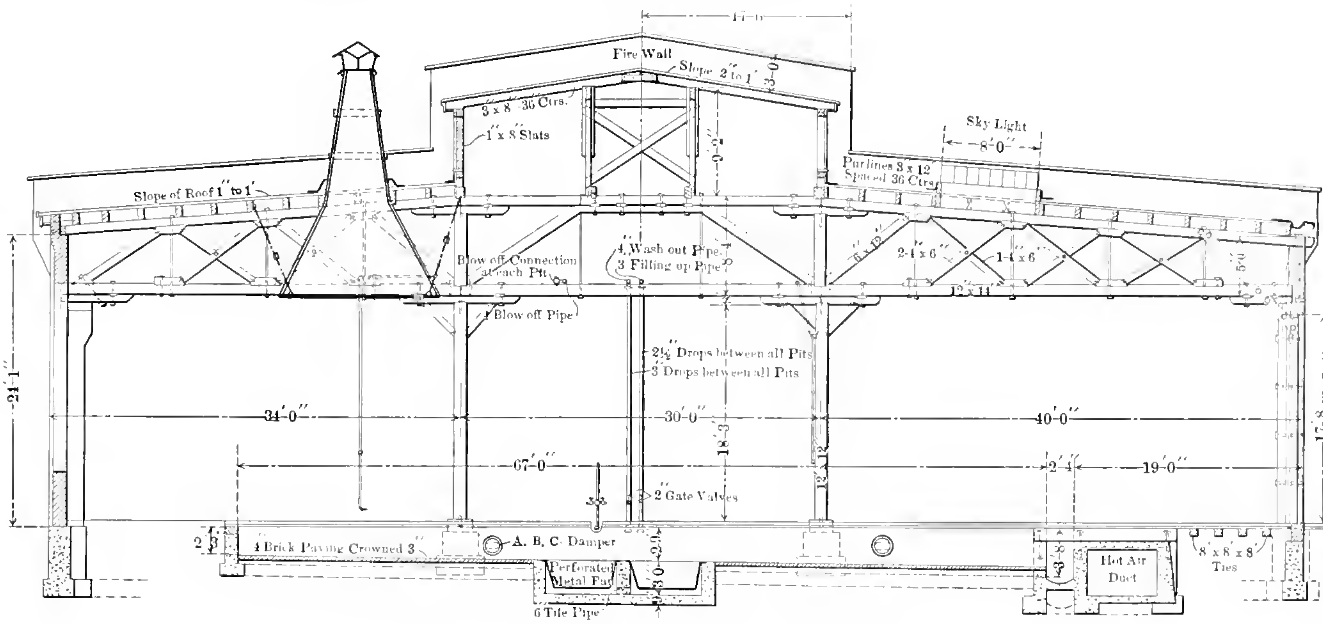
NORTHERN PACIFIC RAILWAY.

A new roundhouse, having some very radical improvements in design and operation, will shortly be placed in commission on the Northern Pacific Railway at Dilworth, Minnesota. The idea, which has been developed by Mr. David VanAlstyne, formerly mechanical superintendent, is to facilitate the handling of engines, especially during severe winter weather when the efficiency of the power is often reduced to an extremely low point, due to inadequate terminal facilities. To accomplish this, arrangements have been made to bring the locomotives directly into the roundhouse as they come off the road, taking time only to coal, water and sand, it being possible to clean the fires on any pit in the house. This will not only make it possible to handle them more expeditiously, thus materially increasing their efficiency at a time when they are needed most, but a considerable saving of fuel will be effected, the expense of hostlering will be reduced and boiler troubles will undoubtedly be relieved to a large extent.

Unfortunately at most terminals the engines usually come in in groups, several arriving at about the same time. While waiting their turn at the cinder pits they often freeze up badly, and this and other treatment which they receive at the hands of the hostlers while waiting, causes more or less boiler leakage. With the new arrangement the engines will be taken directly into the house and the roundhouse force will start to work upon them while they are thawing out. At present the firemen are required

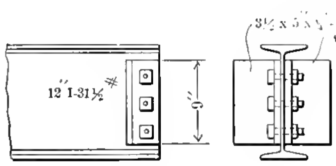


OVERHEAD CONSTRUCTION FOR SUPPORTING I-BEAM TRACKS.



CROSS-SECTION THROUGH DILWORTH ROUNDHOUSE.

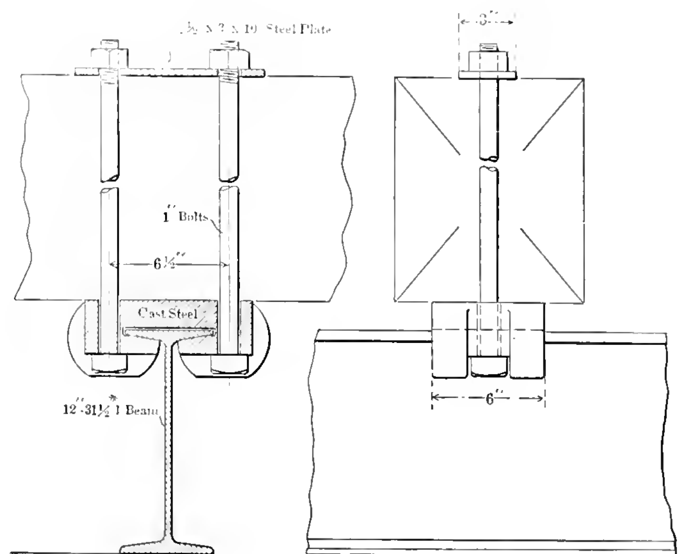
to bring the engines into the terminal with a good fire, but under the new conditions this will be unnecessary, thus effecting a considerable saving in coal. The practice of renewing the fires while the engines are waiting in the yard will also be done away with. Ordinarily the nostler and cinder pit gangs are either overworked or do not have enough to do to keep them busy. With the new roundhouse their work can be arranged to better advantage, materially increasing their average efficiency. As the fires will be allowed to die out gradually, or after being cleaned will be banked, the boilers will not be subjected to extreme and rapid changes of temperature. Steam blown off from such boilers as it will be necessary to wash or repair, will be utilized for heating the roundhouse, or will be blown into a hot well. To bring



SAFETY STOPS AT ENDS OF TRACK.

about this result it was of course necessary to add considerably to the first cost of the roundhouse, but the resulting increase in the efficiency of the power, especially during the colder weather, will, it is expected, many times repay this.

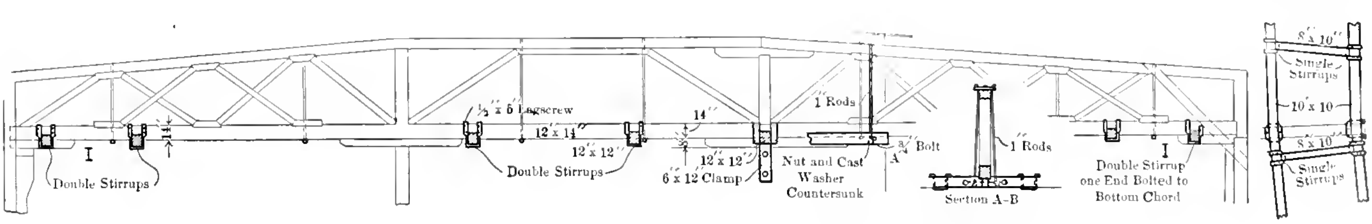
The roundhouse is of brick construction with wooden framing, and has 44 pits, with provision for 9 additional ones should they be required in the future. The plan view shows the general arrangement of the house, with the machine shop, store house, and power plant at one side. The cross section of the house shows the construction of the engine pits; in each of these are two sub-pits, which are normally full of water, each containing a perforated metal pan 6 ft. long and about 30 in. deep. The cinders are dumped into one of these pans and the overhead trolley system is so arranged that when the engine leaves the house the operator of the electric traveling hoist picks up the



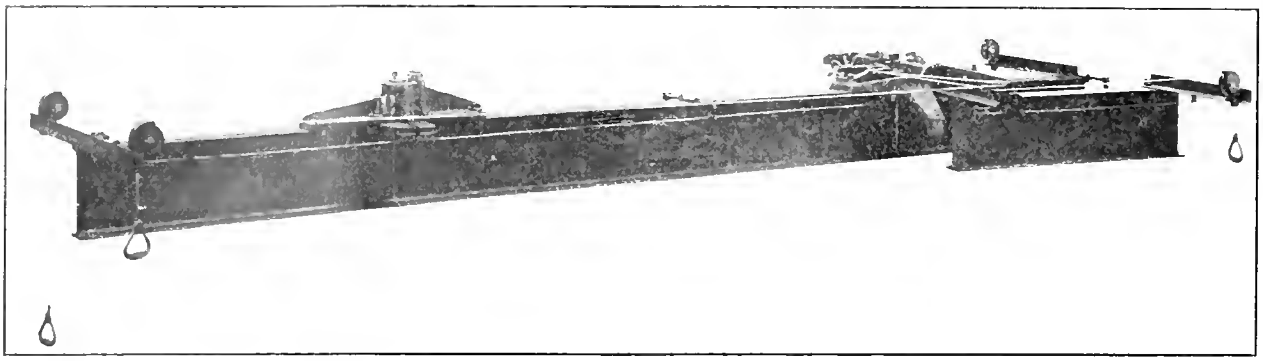
METHOD OF ATTACHING I-BEAM TRACK TO CROSS TIMBERS.

pan, takes it around the inner circle of the roundhouse and dumps it in a car in the cinder shed. He then returns the empty pan to the pit and if the other one is filled, empties it in the same way. Each pan has a capacity sufficient for a large fire, so that if one engine is placed over the pit as soon as another one is taken out there will be room for its fire.

The electric traveling hoist operates on the lower flange of 12 in., 31½ lb. I-beams. The arrangement of the tracks is shown on the plan view; there are 60 two-way switches and one three-way switch. Other views show the arrangement of the framing for supporting these I-beams and the detail methods of attaching them. The trolley has a capacity of 1½ tons, a lifting speed of



GENERAL METHOD OF ATTACHING I-BEAM TRACKS TO ROOF TRUSSES.

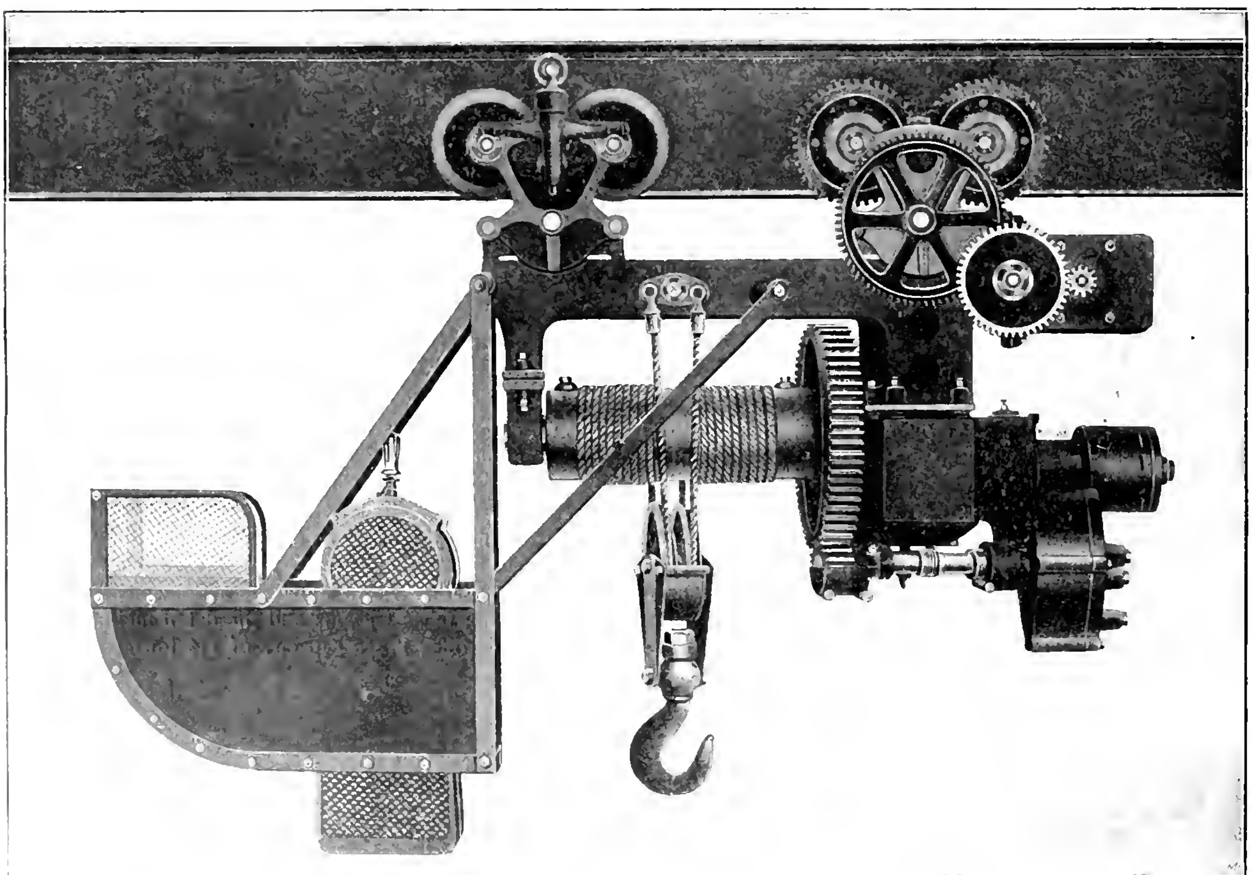


ARRANGEMENT OF TWO-WAY SWITCHES—DILWORTH ROUNDHOUSE.

30 ft. per minute at full load and 60 ft. per minute with no load. The trolley speed under full load is 250 ft. per minute and with no load 350 ft. When not in use carrying ashes the hoist may be used at the front end of the roundhouse for such work as handling front ends, cross heads, pilots, steam chests, etc. The switches are operated by handles attached to the ends of wire ropes. They are so arranged that there is no danger of the trolley running off at an open switch unless the wire rope handles are tampered with, and as these are 15 ft. above the floor there is little danger of this. Although the trolley runs over the drop pits it will be used only for tender and engine truck wheels. A special 5-ton trolley hoist, which is hand operated, will be used for the driving wheels, it being possible to run this hoist into the machine shop and over the driving wheel lathe. The electric trolley will also operate through the machine shop and out over the casting platform. It was furnished by Pawling & Harnischfeger, of Milwaukee, and is known as their two-motor hoist with open cage. It is provided with electric head lights at both ends to enable the operator to see his way in the night time. The power for the plant is furnished by a 165 kw., 60 cycle, 220 volt, 2 phase, direct driven generator. Direct current at 220 volts, for operating the trolley hoist, is furnished by a motor-generator set.

A four-inch pipe for filling the boilers and a five-inch pipe for washing them out extend around the house above the bottom members of the roof trusses, with drops between every other pit. There is also a 5-in. overhead pipe line into which the engines are blown off. During the winter time the steam passes from this into the hot air heating apparatus, the surplus being blown into the hot well. The fan engine also exhausts into this line. The exhaust pipe extends 10 ft. below the water level in the hot well, so that there will always be about 5 lbs. back pressure. The engines, air compressor and pumps exhaust into the hot well through a similar pipe. A by-pass is placed between these two pipes and is so arranged that the exhaust from the power house and from the blow-off can either all be used in the heater, or part of it can be used for this purpose and the rest be blown into the hot well, or all of it can be exhausted into the atmosphere by means of the back pressure valve in the power house. A live steam pipe also leads from the boiler room to the hot well.

In a test, recently made, the power house was operated at its full capacity, as was also the hot air heating plant. The extra exhaust steam was turned into the hot well, heating it up to over 200 degs. F. The large washout pump took the water at this temperature and delivered it to the two farthest washout



PAWLING & HARNISCHFEGER TWO-MOTOR HOIST WITH OPEN CAGE

hydrants in the roundhouse; the 2-in. valves were wide open and the pressure was greater than the boiler pressure operating the pump.

An underground blow-off system is being installed, with connections between the pits, so that engines which are to be washed out may be connected through the blow-off cock, and the dirty water blown into an underground tank which overflows into the sewer. We are indebted for information and drawings to Mr. W. L. Kinsell, mechanical engineer.

ENGINE FAILURES.

By J. F. WHITEFORD.*

Engine failures probably receive more attention than any other one thing in connection with the operation of a railroad, since, when the engine stops, the revenue and all things attendant thereon suffer. Without a well defined system governing the handling of failures it is evident that much energy can be wasted, as the improper charging of failures often results in prolonged debate between the mechanical and transportation departments, which time could be used to better advantage in improving the service.

Engine failures are reported for two reasons:

First: To afford explanation of delays to traffic and affix responsibility.

Second: To furnish such information as will assist the mechanical department in correcting imperfections in design and workmanship.

Delays to traffic will occur as long as railroads are operated, and as an abstract proposition it is immaterial whether the delay ensues from power, rolling stock, roadway or transportation difficulties, but in the interest of the betterment of service, it is imperative that all reports be accurate and that each department bear its own responsibilities.

Delays charged to "engine not steaming" which in reality were due to the inefficient appointing of meeting places, or "working on engine" when a hot box was being cooled on a car or where the improper distribution of ballast destroyed the efficiency of the cylinder cocks, have no tendency toward improvement and these illustrations serve to indicate the necessity of a well defined system of reporting and tabulating failures.

It seems essential, in a discussion of this subject, that the following be considered.

A concise definition of an engine failure.

A proper method of reporting and tabulating failures.

A satisfactory basis for comparing failures.

A systematic course for improving conditions.

Owing to the various causes which may retard the departure of an engine from a roundhouse, it does not seem proper to include terminal delays in the list of failures. These should be handled independently and only such delays as result after the engine is in actual service should be considered, as failure reports should serve as an indication of the condition of power.

All delays to traffic due to the condition of the engine, which are not afterwards overcome, should be charged as failures, but the value of the reports diminishes rapidly when failures are listed that were the immediate result of excessive delays on side tracks, damaged rolling stock or bad condition of the roadway. This emphasizes the necessity of stringent rules covering these details, as failures once charged should never be cancelled.

It is obvious that the mechanical department knows more about the handling of power than the transportation department, and that the latter knows more about the handling of trains than the former, so that it should not be a difficult matter to properly define an engine failure, but when discussions are permitted relative to the charging of a failure, which was primarily due to transportation or roadway difficulties, it is essential that rules be made to cover all these details and when once made, that they be rigidly enforced.

Since the effect produced by those causes which tend to decrease the efficiency of a locomotive, varies with the size and service of the engine, the water conditions and the topography of the country, it is improbable that a definition of a failure could be arranged that would be universal in all sections of the country, though it is possible to have one common in part, if not in entirety, leaving the adjustment of the details to those in immediate charge. These, when once arranged, would enable the train dispatcher to charge all failures correctly upon the receipt of a separate report from the conductor and engineer, which ruling should be effective in order to effect uniformity in all reports of delays and remove the liability of errors.

A telegraphic report, to be followed by a copy by mail, of all failures where the engine is concerned, should be furnished each morning to the heads of all departments, and the roundhouse foreman should have complete information of failures, so that a thorough examination and subsequent report can be made immediately on the arrival of the engine at the terminal.

A blank form should be furnished the engineer to be filled out on his arrival, permitting the mentioning of such details as may be necessary to supplement the telegraphic report, and his statement, together with the one from the roundhouse foreman, should be in the master mechanic's or division foreman's office within five hours after the arrival of the engine.

Where machinery is broken, a "defective machinery blank" properly filled out should accompany the other reports, as the cause of all failures of power cannot be followed too rapidly or too thoroughly.

Provision for the handling of these reports beyond the master mechanic's office should be made to suit conditions on each individual road in order that imperfections in design may be corrected as early as possible, and instances of inferior workmanship may be handled as conditions permit or necessities require.

A monthly report where all the failures occurring on each operating division are shown, should be issued and all failures itemized as follows:

Hot Bearings	*Machinery*
Driving boxes	Piston loose
Engine trucks	Piston bent
Tender trucks	Piston gland broken
Eccentrics	Piston heads broken
Crank pins	Piston follower broken
Etc., etc.	Etc., etc.

A suitable comparison should be made as regards the total failures on each division with the preceding month or that of a year previous.

Since the monthly report cannot reach the various division offices for three or four weeks after the last of the month, the writer has found it of considerable advantage to separate the failures shown on the daily reports into the following general heads:

Air	Machinery
Blow-off Cocks	Oil Burners
Grates	Foaming
Hot Bearings	Leaking
Injectors	Not Steaming
Miscellaneous	

By such a system, an unusual number of failures of any one of the foregoing classes are readily discovered and such action immediately taken as may be necessary for improvement. Much good may be accomplished by the master mechanic's office furnishing the various sub-foremen with a copy of the failures for each week with comparison of the preceding week, showing the failures of each class on engines leaving the various terminals separately.

A satisfactory comparative basis is very necessary, as otherwise it will be impossible to make accurate comparisons of different divisions for the same period and of the same division for different periods, but after a thorough investigation of the situation, it appears that the common comparative factor—average mileage per failure—is not only inadequate but very misleading, as numbers only are considered, regardless of the variations of detriment to the service that result from the failure.

Since the primary reason for the reporting of failures is to

* General Roundhouse Inspector, Santa Fe.

explain delays to traffic, it is imperative that the extent and importance of the delays should be considered in making comparisons, as a delay of eight hours is more detrimental to the service than one of five minutes, and delays to passenger trains are of more relative importance than those to through freight and the latter in turn are more important than those to local and switch service.

In the days when engines were of the same size and total failures were the only ones counted, the necessity of checking delays was not as vital as at present. The number of failures only was sufficient for comparative purposes, but since a failure may be anything from a three-minute delay to where the engine gives up the train, it is evident that the numerical feature is not sufficient.

A storekeeper whose records of a stock of pipe consist of the number of feet of pipe, regardless of the diameter or quality, would be in bad shape, which illustrates that the number of failures are meaningless without some additional information relative to the damage to the service, and while this may necessitate more clerical work, I am of the opinion that the needs justify the expense, as otherwise it will be impossible to determine whether any improvement is being effected.

For example, consider the following failures:

Eng.	*Train*	*Time*	*Cause of Delay*
107	4	2 hr. 40 min	Broken piston rod on air pump. Delayed No. 4, 2 hr. 40 min. waiting for No. 77's engine. Delayed No. 77, 6 hr. 30 min. waiting for another engine.
1732	33	1 hr. 55 min.	Blew out cylinder head, reduced to 40 per cent tonnage.
2821	Loc. E	20 min.	Packing hot box on engine truck.
2112	Switch	30 min.	Broken brake rod. Delayed yard work 30 min. while engine went to roundhouse for repairs.

The foregoing failures, varying from a total failure where a limited train was delayed two hours and forty minutes and a fast freight six hours and thirty minutes to that of a failure where a local train was delayed twenty minutes, while differing largely as to extent and importance of the delay to traffic, are all of the same value where numbers only are considered.

It seems advisable to divide failures into three divisions, namely: passenger, time freight, local and switch.

These divisions when all failures are reduced to a total hour delay in the first and third classes and a tonnage hour delay in the second class, would enable very satisfactory comparisons to be made and those in charge of operation would be able to determine accurately, from the monthly report showing the total delays resulting from failures, the extent of improvement or otherwise on any and all divisions. Under the present system, ten failures of five minutes each are considered of more consequence than five where the engine fails entirely and gives up the train, which is incorrect altogether, since the service was impaired more in the latter case than in the former.

For the improvement of conditions or the diminishing of failures, it seems necessary to have a prompt, explicit and correct report followed by a thorough investigation and the necessary action taken to correct imperfections in design and workmanship.

Efficient supervision is the only remedy and should exist not only in the roundhouse, but on the road, as many failures due to carelessness on the part of the workman could have been avoided if the enginemen had given their engines the proper attention.

When one engineer can run an engine successfully without a failure for six months and another on the same service under identical conditions has an average of one failure per week, it indicates that much improvement can result from the co-operation of the enginemen.

However, but little good can result from asking an engineer to "please say why" he had a leaking failure after he had remained on a side track an excessive time, or a hot bearing when it was necessary to use a freight engine for passenger service, which again illustrate the necessity of a concise definition of a failure, as the engineman should get full credit for meritorious service in this respect.

In connection with the proposed methods of tabulating engine failures, the monthly report could be arranged so as to show the total delays resulting from each individual engine, which in cases of assigned engines should serve as a record of individual engineers. The establishing of a system of giving merit marks according to the decrease in delays, would have a good effect. A report of this nature would permit the condition of each engine in service to be reflected without the introduction of individual foreman's opinions, as the first report is usually correct, while the latter is only a matter of conjecture.

A rigid inspection on the arrival and departure of an engine at a terminal by both the engineer and roundhouse man, and the constant attention of the enginemen while on the road, will serve to improve the service of a locomotive, and with such corrections of imperfections in design as may be determined from the reports of failures, is all that those in immediate charge can accomplish, though the care of an engine both on the road and at the terminal should occupy the attention of all in the operating department.

TESTS OF GAS ENGINES WITH ALCOHOL FUEL.

Bulletin No. 191 of the U. S. Department of Agriculture, recently issued, contains a full account of a series of experiments made for the purpose of testing the adaptability of the present designs of gas engines in America to run on alcohol as fuel, as well as the efficiency and action of this fuel as compared with gasolene or kerosene. Tests were made on eight different engines, including one, two and four cylinder and two and four cycle engines, for both low and high speed. A sufficient number of runs were made with each engine to obtain uniform and accurate data. The conclusions drawn as a result of this investigation are:

1. Any gasoline engine of the ordinary type can be run on alcohol fuel without any material change in construction. Difficulties likely to be encountered are in starting and in supplying a sufficient quantity of fuel, a quantity which must be considerably greater than the quantity of gasoline required.

2. The operation on alcohol is more noiseless than gasoline; the maximum power is materially higher and there is no danger of injurious hammering.

3. Alcohol seems to be especially adapted as a fuel for automobile air-cooled engines, since the temperature can rise much higher than with gasoline before auto-ignition takes place.

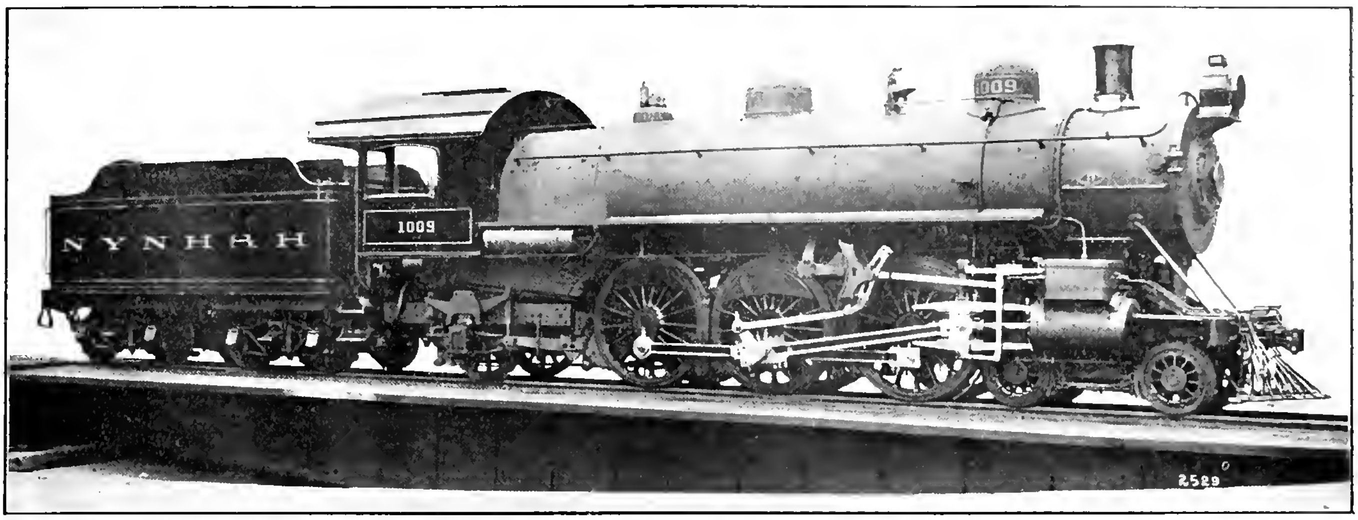
4. The consumption of fuel of any kind in pounds per brake horse-power depends chiefly upon the horse-power at which the engine is being run and upon the setting of the fuel supply valve. It is easily possible for the fuel consumption to be double its best value, either by running the engine underloaded or by a poor setting of the fuel supply valve.

5. So far as tested the alcohol fuel consumption was better at low than at high speeds. Increasing the initial compression from 70 to 125 lbs. produced but very slight improvement in the consumption of alcohol.

6. With any good small stationary engine as small a fuel consumption as .7 lbs. of gasoline or 1.16 lbs. of alcohol per brake horse-power hour may reasonably be expected under favorable conditions. These values correspond to 0.95 pints of gasoline and 1.36 pints of alcohol.

Report of Car Surplus and Shortage.—The report of the committee on car efficiency of the American Railway Association, given in statistical bulletin No. 7, shows that on September 18, on 172 roads, the surplus of revenue freight cars was 13,231 and the shortage 64,929. On October 2 reports from 149 roads showed a surplus of 6,202 cars and a shortage of 64,013.

Passenger Traffic on the Long Island Railroad.—During the first eight months of this year the Long Island Railroad carried 16,831,076 passengers, an increase of nearly two million over the number carried in the same months of last year. This is an increase of 11.6 per cent.

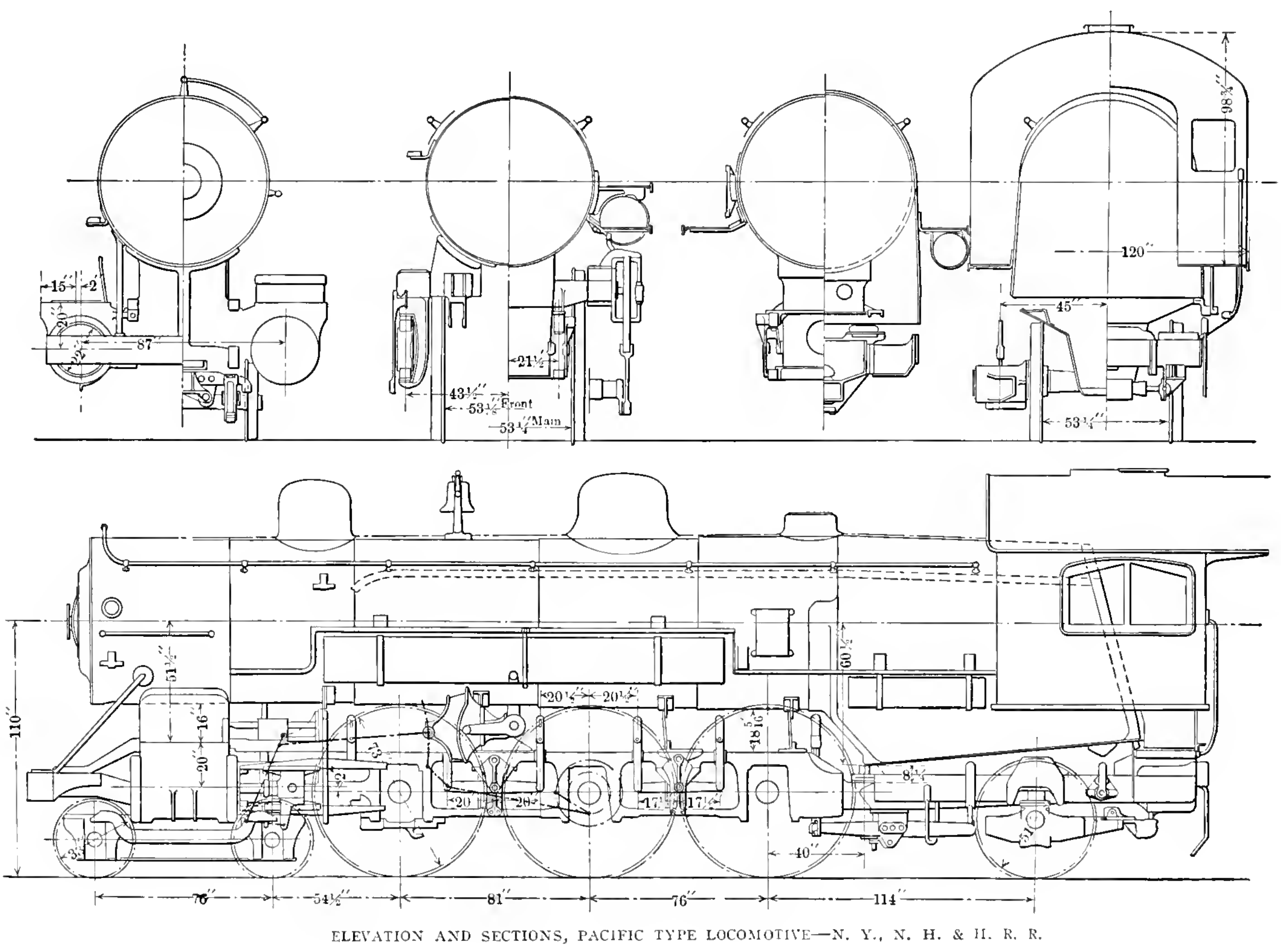


PACIFIC TYPE PASSENGER LOCOMOTIVE—NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

PACIFIC TYPE LOCOMOTIVE.

NEW YORK, NEW HAVEN AND HARTFORD RAILROAD.

The motive power on the New York, New Haven & Hartford Railroad, for passenger service, has heretofore included but two types of locomotives, the eight-wheel, or American type, for the lighter class of passenger and suburban trains and the ten-wheel type for the heavier suburban and through express trains. The train schedules of this road demand several trains each day between New York and Boston, a distance of 232 miles, to operate between terminals in five hours. These trains have been handled by a ten-wheel type of locomotive having 21 x 26 in. cylinders, 73 in. drivers and a total weight of 165,950 lbs., of which 132,000 lbs. is on drivers. They have a tractive effort of 26,700 lbs. These engines proved perfectly satisfactory up to the limit of their capacity. This service, however, has become so popular, and since the equipment used is of the most luxurious and modern type, consisting only of heavy Pullman cars, the weight of the trains has become so great as to exceed the steaming capacity of the locomotives. It is not unusual for these trains to consist of 13 or 14 cars, and seldom do they run below 12 cars having a weight of 550 tons. An added car or so has made it impossible for the ten-wheel locomotives to maintain their schedule, largely on account of lack of steam, and a new design of locomotive of the Pacific type has been designed for service on these trains.



ELEVATION AND SECTIONS, PACIFIC TYPE LOCOMOTIVE—N. Y., N. H. & H. R. R.

The Baldwin Locomotive Works has delivered 21 of these engines and the American Locomotive Company 9, all being built from the same drawings. The illustrations which accompany this article are of the Baldwin engines.

The accompanying table will give an opportunity for comparison of the Pacific types with the ten-wheel locomotives in this service and it will be seen that while there has been an increase in the size of the cylinders from 21 x 26 in. to 22 x 28 in., which

Type	4-6-2	4-6-0
Tractive effort, lbs	31,600	26,700
Total weight, lbs	227,000	165,950
Weight on drivers, lbs	134,250	132,000
Cylinders, diameter and stroke, inches	22 × 28	21 × 26
Diameter drivers, inches	73	73
Heating surface, total square feet	3,935	2,665
Grate area, square feet	53.5	34.7
Weight drivers ÷ total heating surface	34.2	49.5
Tractive effort ÷ total heating surface	8.05	10.
Weight drivers ÷ tractive effort	4.25	4.94
Heating surface ÷ grate area	73.5	76.8
Heating surface ÷ cylinder volume	317.	257.
B. D. factor (T. E. × diam. driv. ÷ heat. surf.)	587.	730.

has resulted in an increase of tractive effort of about 5,000 lbs., there has been but little increase in the weight on drivers. The principal change noticed is in the boiler capacity, which has been increased nearly 50 per cent. in heating surface, and over 55 per cent. in grate area, thus giving 34.2 lbs. weight on drivers per sq. ft. of heating surface instead of 49.5, and also giving 1 sq. ft. of heating surface to about 8 lbs. tractive effort instead of 10. An inspection of the B D factor clearly indicates that the capacity of the new locomotives for continuous high speed work is a large improvement over the previous engines.

These locomotives in size and capacity are very similar to those built by the Baldwin Locomotive Works for the Chicago, Burlington & Quincy Railway, which were illustrated on page 300 of the August, 1906, issue of this journal. The Burlington engines, however, have a much larger proportion of their weight on drivers, giving a ratio of 65.5 per cent. of the total weight on drivers, while the New Haven engines give but 59.5 per cent., and although the tractive effort of the former, due to the 1 in. larger drivers, is 500 lbs. less, the ratio of adhesion is 4.8, while that of the New Haven engines is but 4.25. In other respects the two designs differ only in such details as trailer truck, valve gear, valves, etc.

The boiler, which is shown in one of the illustrations, is of the straight top type, the barrel being built up of four rings with the seams placed on the top center line. In the dome course the seam is welded throughout its length on each side of the opening, the other seams being welded only at the ends. All have the diamond form of inside welt strips. The fire box is of the radial stay type with crown and side sheets in one piece, as are also the outside and roof sheets. This type of fire box sheets has been the standard practice on the New Haven road for some time and has been found to be very satisfactory. It is the custom, when it becomes necessary to renew the side sheets, which of course will need renewing before the crown under ordinary circumstances, to cut the sheet and put the new side sheet in in the same manner as would be done with a three-piece fire box. Four 3-in. water tubes are provided in the fire box for supporting the brick arch. An inspection of the illustration will show that the feed pipes are of the internal type, feeding through a double check valve on the back head to a pipe leading forward to a point near the front tube sheet, where it is curved downward.

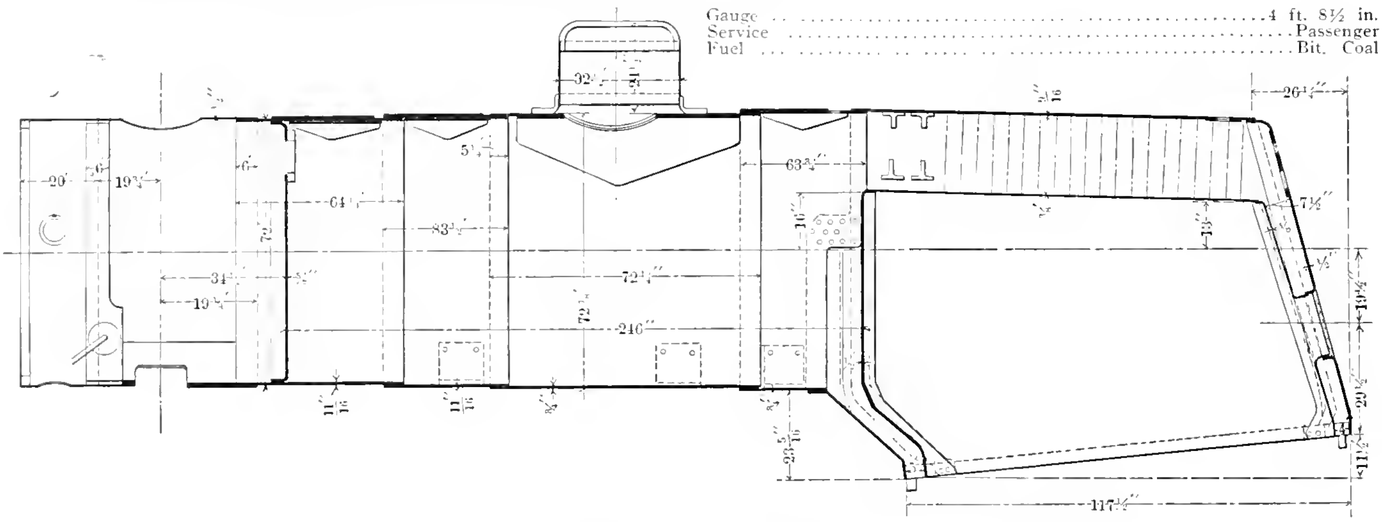
The cylinders are of the usual slide valve pattern, the valves, however, being offset 2 in. outside of the cylinder center to eliminate the use of a rocker arm in the Walschaert valve gear. Cast iron bushings ⅝ in. thick are fitted in the cylinders.

The design of the valve gear differs somewhat from that shown on recent examples of Pacific type locomotives illustrated in these columns, in that the link is supported from an extension of the frame cross tie between the first and second pairs of drivers, much the same as would be done with a consolidation or Prairie type locomotive.

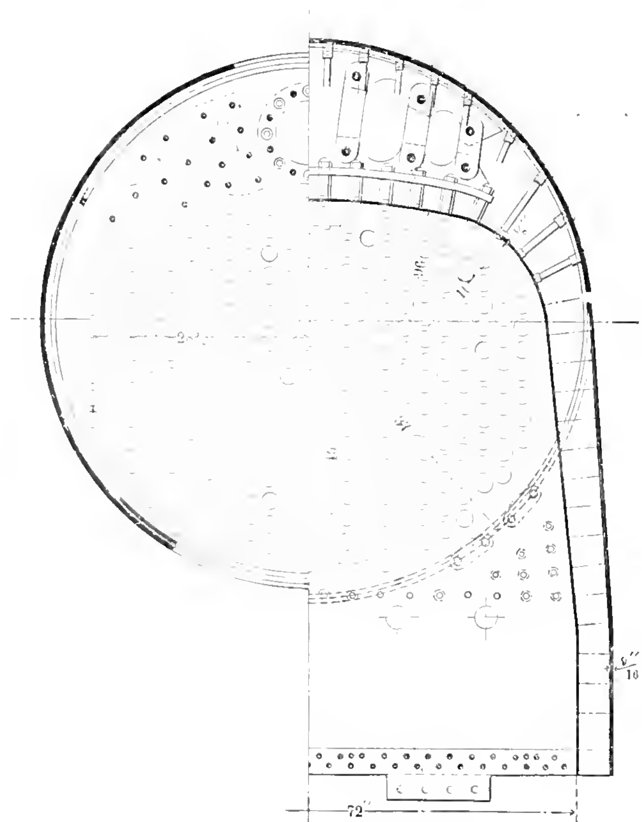
The general dimensions, weights and ratios of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal



LONGITUDINAL SECTION OF BOILER, PACIFIC TYPE LOCOMOTIVE—N. Y., N. H. & H. R. R.



CROSS SECTIONS OF PACIFIC TYPE LOCOMOTIVE BOILER.

Tractive effort	31,600 lbs.
Weight in working order	227,000 lbs.
Weight on drivers	131,250 lbs.
Weight on leading truck	48,550 lbs.
Weight on trailing truck	44,200 lbs.
Weight of engine and tender in working order	357,000 lbs.
Wheel base, driving	13 ft. 1 in.
Wheel base, total	33 ft. 5½ in.
Wheel base, engine and tender	61 ft. 2 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.25
Total weight ÷ tractive effort	7.18
Tractive effort × diam. drivers ÷ heating surface	587.00
Total heating surface ÷ grate area	73.50
Firebox heating surface ÷ total heating surface, per cent	5.45
Weight on drivers ÷ total heating surface	34.20
Total weight ÷ total heating surface	57.80
Volume both cylinders, cu. ft.	12.40
Total heating surface ÷ vol. cylinders	317.00
Grate area ÷ vol. cylinders	4.32

CYLINDERS.

Kind	Simple
Diameter and stroke	22 × 28 in.
Kind of valves	Bal. Slide
Greatest travel	6⅞ in.
Outside lap	1 3/16 in.
Inside clearance	⅛ in.
Lead, constant	5/16 in.

WHEELS.

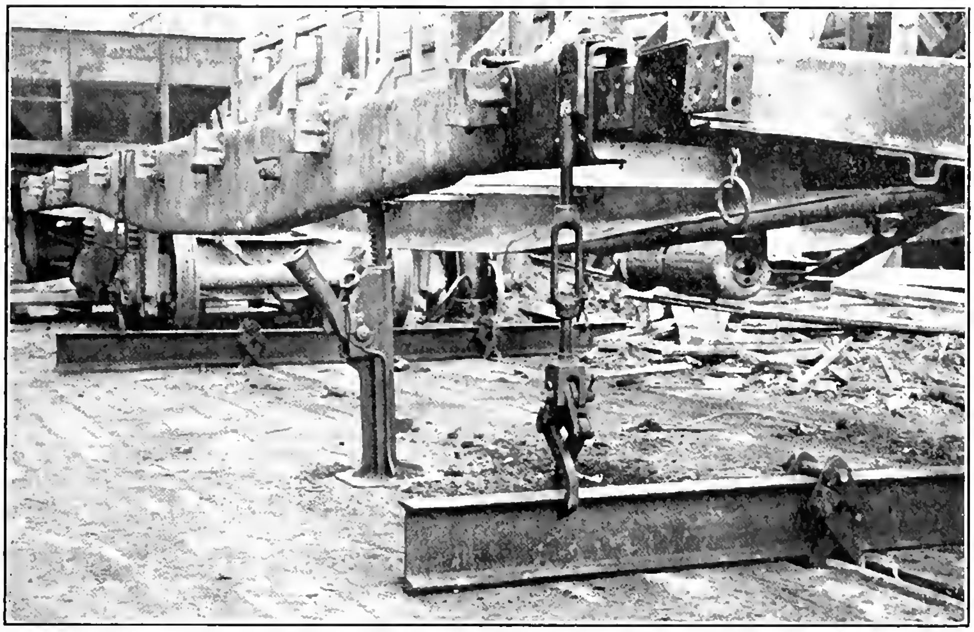
Driving, diameter over tires	73 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 × 12 in.
Driving journals, others, diameter and length	9½ × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6 × 12 in.
Trailing truck wheels, diameter	51 in.
Trailing truck, journals	8 × 14 in.

BOILER.

Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	70 in.
Firebox, length and width	108⅛ × 71¼ in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	F-5, S & B-4 in.
Tubes, number and outside diameter	310 2¼ in.
Tubes, length	20 ft 6 in.
Heating surface, tubes	3720 sq. ft.
Heating surface, firebox	186 sq. ft.
Heating surface, water tubes	29 sq. ft.
Heating surface, total	3935 sq. ft.
Grate area	53.5 sq. ft.

TENDER.

Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	6000 gals.
Coal capacity	14 tons

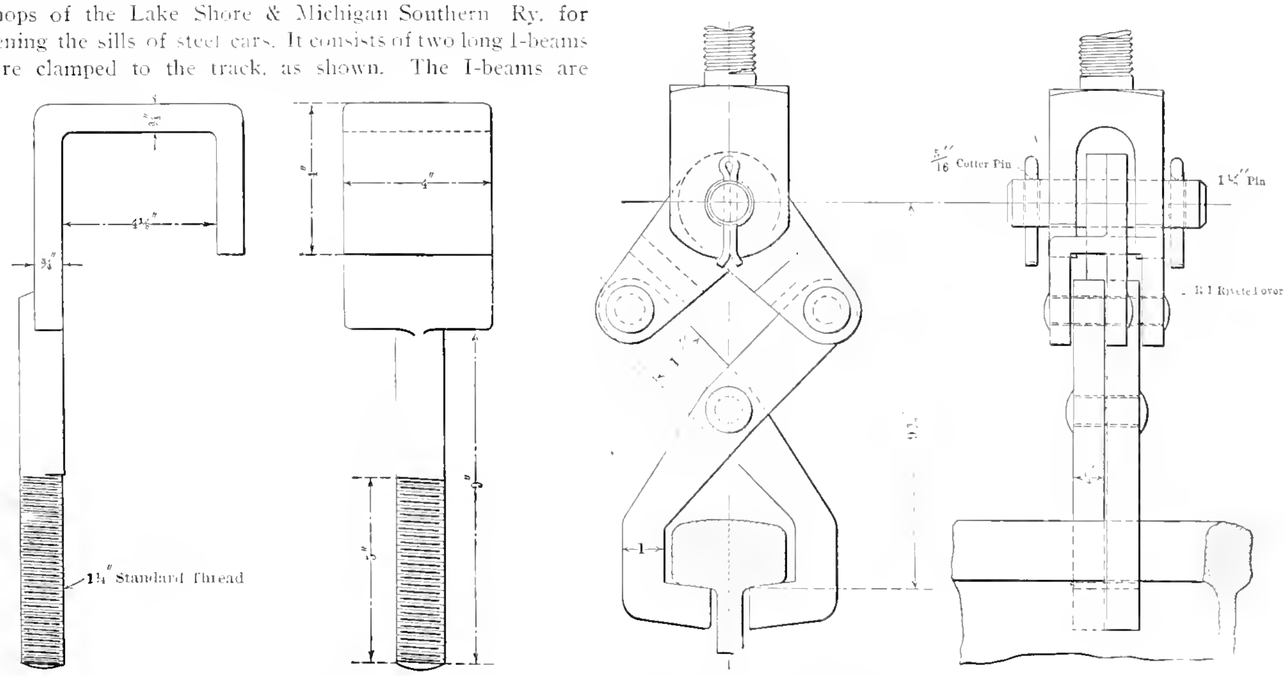


STRAIGHTENING THE SIDE SILLS OF A STEEL CAR.

A DEVICE FOR STRAIGHTENING THE SILLS OF STEEL CARS.

The illustrations show a device which is in use at the Collinwood shops of the Lake Shore & Michigan Southern Ry. for straightening the sills of steel cars. It consists of two long I-beams which are clamped to the track, as shown. The I-beams are connected to the hooks which fit over the top of the sill by turnbuckles and clamps, similar to those which hold the I-beam to the rail. By placing a jack underneath the sill, at the proper point, it is an easy matter to straighten it by screwing up the turnbuckles. The device is simple and may easily be moved to any point in the repair yard by two men. There is no reason why it cannot do the work as well as the more complicated devices in use, which are permanently placed, requiring the car to be brought to them.

POWERFUL ELECTRIC LOCOMOTIVE.—It is reported that a 4,000 h.p. electric locomotive has recently been completed by the Westinghouse Electric & Mfg. Company, which was designed to fill the conditions of the Pennsylvania Railroad for service in its tunnels near New York City. As these tunnels will have very steep grades over which the traffic must be handled at high speed, very powerful machines will be needed. It is not stated whether this locomotive is in more than one section.



DETAILS OF DEVICE FOR STRAIGHTENING THE SILLS OF STEEL CARS.

(Established 1832).

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Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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NET EARNINGS OF A LOCOMOTIVE.

The discussion of Mr. Toltz's paper on "Steam vs. Electric Locomotives" at the September meeting of the New York Railroad Club brought out some very sane comments on this subject, over which there has been so much discussion during the past year. One speaker pointed out that to obtain many of the advantages claimed for electric locomotives there would have to be a big improvement in the operating conditions of through passenger and freight trains. These changes will take considerable time during which there will undoubtedly be improvements in the steam locomotive, making it a more efficient machine. At present the growth of the locomotive has surpassed the extension of other factors in railroad operation and it is probable that it will maintain its lead. Another speaker stated that even if the fabulous figures mentioned in the paper, as a possible saving by the application of several devices to the present locomotive, could be realized it would make no difference in the introduction of electric locomotives. They will be used in certain localities regardless of cost. He brought out the basic truth of the whole matter by saying "that a locomotive is valuable *not* for what it saves but for what it earns above what it costs." If electric locomotives can show greater net earnings they will be used even if their operating expenses are much greater. Also in applying improvements to steam locomotives it is the net results that should be kept in view. It is not sufficent that a device will save 10, 20 or 30 per cent. of the fuel. It must do it without a proportional increase in other expenses. A superheater which will save 15 per cent. of the fuel and water would be of no value if it holds the engine in the roundhouse three or four hours longer than would be otherwise required or if it compels a reduction of tonnage rating, or the cutting out of tonnage on the road. The locomotive must do the work it was designed for first and make what saving it can secondly. While we believe a net saving can be made with superheaters, feed water heaters, variable exhaust nozzles, etc., we do not believe that it will be made by a reduction of the present expense, but rather bv providing a largely increased earning capacity with a proportionally smaller increased operating expense.

RAILROAD CLUBS.

One of the most important functions of our railroad clubs should be to get the younger men interested and to encourage them to take an active part in the work of the club. To attract this class of men, and most of them are working hard to get started and are not overpaid, the financial demands should be kept at a minimum and "full dress" affairs and features of this kind should be discouraged. This holds true also of a large class of capable, ambitious men, such as shop foremen, who ofttimes form the most valuable part of the membership. If the special features are such as to exclude such men, or to impose a hardship upon them, it tends to promote class distinction which should earnestly be guarded against. A railroad club composed of a few of the higher paid officials and a lot of supply-men will not be of any great practical value.

* * * * * * *

Some personal work will undoubtedly be required on the part of the officers to stir up the young men and get them started. Much may be accomplished by picking out a few of the most promising ones and personally asking them in advance to be prepared to take part in the discussion of some paper in which they are specially interested. As a rule they will feel honored by such a request and will do their best to "make good." After two or three such occasions they will begin to feel more at ease and much may be expected of them.

Ordinarily to make a meeting a real success the officers should see that certain persons, with an intimate knowledge of the topic, are prepared to open the discussion. This practice, however, may be easily overdone. When the entire discussion is "cut and dried" in advance, and only a favored few have an opportunity of participating, the real usefulness of a club is likely to begin to wane. This does not mean that members should not carefully prepare their discussion in advance, but that the practice of specially inviting too many to take part and formally announcing them, one after another, so that there is practically no time for open discussion, should be discouraged. If members would read the paper of the evening over carefully and prepare their discussion in advance the proceedings could be improved, in some cases, at least one hundred per cent.

The proceedings of the Society of Railway Club Secretaries shows that three railroad clubs have gone out of existence during the past year. The Pacific Coast Club did not survive the San Francisco disaster, the Southern & Southwestern Club and the North-West Club seem to have both lapsed into a state of apathy. All three of these have done splendid work in the past and it is to be sincerely hoped that they will again become active, as nothing can do so much toward getting the railroad men in the various districts acquainted with each other, so that they may interchange ideas and receive inspiration. One club, at least, failed because, although there was a good attendance at the meetings, the work and responsibility of keeping it up seemed to rest on one or two men. Whose fault was this? It behooves the members and officers of each club to study conditions carefully and strengthen up the weak points.

DILWORTH ROUNDHOUSE.

The results of the operation of the new roundhouse on the Northern Pacific Railway at Dilworth, Minn., during the coming winter, will be awaited with great interest. Just as the machine shop is the critical point as concerns output, in most of our railroad shops, so the cinder pit is often the critical point at the roundhouse, and this is especially true during the severe winter weather in the northern part of the country. Entire divisions are often blocked during the colder, stormy weather because of the failure of power, due both to overloading and to inadequate facilities for properly taking care of the locomotives at the terminals. The Northern Pacific is taking "the bull by the horns" and at a considerable expense has installed a roundhouse to relieve the troubles incident to the holding of engines out of doors until their fires can be cleaned at the cinder pit. Radical changes have been made from the ordinary methods of design and these will necessitate equally radical changes in the method of handling the locomotives. The roundhouse is an experiment, but the indications are that it will prove very successful.

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On the average, approximately half of the delay and expense to engines at terminals is in handling them in and out of the house. It is not possible to reduce the time required for repairs to any extent so that any material saving effected must be in the handling. The chief delay in handling is caused by engines arriving at the roundhoue in fleets, and there being only one or two ash pits, it takes a long time to get the last engine in the house. In a cold climate where engines arrive at terminals with ash pans frozen up, it takes considerable time to either thaw or chip the ice out of the pans so that the fires may be knocked out. The firemen are required to bring engines into terminals with good fires and the boiler filled with water, because of the necessity for keeping engines hot while they are waiting their turn at the ash pit. During the time they are waiting, hostlers burn a great deal of coal and use the blower excessively to the injury of the boiler. It very often happens that engines go to the ash pit with a lot of green coal and fresh fire which is knocked into the pit and the coal is thus wasted. While the engines are waiting outside, it is impossible for machinists and boiler makers to get at them for repair work.

In the Dilworth roundhouse, the outside ash pit is not to be used except in emergency. A positive order can be issued which will prohibit having an engine outside the house to exceed thirty minutes after its arrival at the terminal, provided there is a vacant pit in the house for it. As soon as the engine arrives at the terminal, it will be given coal, water and sand and run immediately into the house. If the boiler is to be washed out, the fire will be knocked into the pit at once. If not, the fire will be left in the firebox to die out gradually and when dead the ashes will be knocked into the pit. Keeping the fire in an engine until it dies out will be an advantage to the flues as a more uniform temperature will be maintained in the boiler. It will also generate more or less steam for use in heating the house or heating water for washing out. By allowing the fire to die out in the fireboxes it is thought that there will not be much trouble on account of smoke and gas in the roundhouse. It is estimated that a considerable amount of time will be saved between the arrival at a terminal and the time an engine is ready for departure and that in addition there will be a saving in coal and labor of from $1.00 to $5.00 per engine handled. At this rate of saving the additional cost of the installation would be paid for in a short while.

THE APPRENTICE QUESTION.

The first conference of the apprentice instructors of the New York Central Lines marks the first milestone in the movement for improved apprenticeship conditions on that system. This new system, based on broad, common sense, rational lines, has become well established and while much still remains to be accomplished the splendid progress made thus far, and the strong organization which has been built up, promises well for the future.

The first question which will undoubtedly suggest itself to those who are studying conditions, with a view of establishing a similar organization, will be: Where did the drawing and shop instructors come from? How were they selected? The answer reflects considerable credit on those in charge of the work on the New York Central. In every case the men were selected from the force at the local shops—the drawing instructor being, in most cases, a shop draftsman; the shop instructor a mechanic, who was not only master of his trade and acquainted in a general way with the allied trades, but a man who could understand boys. They are all practical men and some of them have had to study hard to keep up with the school work and yet, to a man, they have been remarkably successful. Is not this a reflection on those companies who are continually going outside of their own organization to find men for special work? Is it because the proper men are not already at hand, or is it because the management is not big enough to find them?

The instructors are urged to think for themselves and not to depend to too great an extent upon the detail instructions laid down by the central organization. Many problems come up which require individual treatment. The instructors are in direct contact with the boys and can see whether the work arranged at headquarters is accomplishing the desired result. They are, therefore, encouraged to criticise and suggest improvements and the following out of such suggestions has added greatly to the success of the work. This freedom of expression on the part of the instructors was especially noticeable at the conference and was undoubtedly responsible for bringing out such a large amount of good, practical information.

We make no apologies for devoting so much space to the apprentice question in this issue. It is one of the most important now before the railroads and industrial concerns of this country and they need all the help they can possibly get to assist them in handling it properly. The proceedings of the conference form a valuable record of the difficulties surmounted during the beginning of the work and suggestions as to future conduct.

* * * * * * *

In establishing an apprentice system two things must be carefully avoided. Do not make the entrance requirements too hard and do not try to cover too much ground in the educational work. Remember that the prime object is to make good mechanics and that the turning out of foremen and higher officials is purely incidental. If you have nothing but high school graduates for apprentices you will gain but very few mechanics, for such men are usually fitted for better positions after they have received their practical training. If you insist on covering too much ground you will discourage and drive out the slower boys, and these are just the ones who will make the future men in the ranks. Good, conscientious work, in encouraging and helping men of this kind to gain a broader view of their work and their place in the organization, and most important of all to teach them to think for themselves, will produce untold future results.

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The moral training of the apprentices should not be neglected, in fact it should be one of the most important features of the

system. The work which is being done along these lines is clearly brought out in the two papers by Mr. Rausch. The instructor to bring about such results must be a clean, clear cut man morally, with a big heart and a kindly feeling for the boys.

* * * * * * *

Possibly the most interesting part of the conference was the discussion of the practical benefits derived from the school work. The New York Central was not looking for immediate results when it started the new apprentice system. The management was far sighted enough to look five, ten, or fifteen years ahead, feeling sure that they would be amply repaid at that time. Four hours of working time devoted to school work each week by each apprentice amounts to quite an item, but apparently the practical returns already at hand, due to the school work alone, do much to off-set this. In this connection it is important to note that although a shop instructor has not as yet been appointed at the Oswego shops, important practical results are evident, which must be almost entirely due to the school training which the apprentices have received.

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At the October meeting of the American Society of Mechanical Engineers, Prof. J. P. Jackson of State College, Pa., presented a paper on college and apprentice training. This dealt largely with what on our railroads has been known as special apprenticeship, or the training of the college graduate. Fortunately most of the railroads are doing away with this and the technical graduate is taken into the shop on the same basis as the regular apprentice and his advancement depends entirely upon his ability. The right time for a college man to receive his practical training is previous to or in connection with his college work. The second alternative is a difficult one to fulfil unless the students take things into their own hands and get their practical experience during summer vacations and by taking a year or two off for it, during the college course. The University of Cincinnati has adopted a method by which the students spend alternately two weeks in the class room and two weeks in the works of local manufacturers. Their summer vacations are also spent in the shops. The course is six years long, and without any question it will graduate *real* engineers. The proper relation between the college man and the regular apprentice is clearly brought out in the following extract, which is taken from remarks made by Mr. G. M. Basford in discussing Prof. Jackson's paper.

"It is well to provide for the college man; it is, however, a mistake more serious than most of us can now realize to provide for them unless we have previously put our shop recruiting system for the workmen—the men who do our work—upon a proper basis. I cannot find the words to say, as it ought to be said, that college graduate apprenticeship is wrong from every standpoint unless based upon and preceded by a proper recruiting system and what we generally understand by the term, "regular apprenticeship."

"If we have a proper regular apprenticeship system we have a moral right to deal with college graduate apprenticeship. If we have not such a system, we have no such right and we are making an error for which we shall in time pay dearly. It is easy to realize that this is not a proper sentiment to express, but a warning is evidently needed lest we build our pyramid upon its apex. We stand in need of captains and a few subordinate officers, but we stand in greater need of an intelligent rank and file. In developing the first class let us not kill the second. If we had a good organization as to the rank and file, the captains and subordinate officers would not constitute a problem. *It is from the rank and file that we always have and always will develop leaders. We shall suffer in the long run for any policy which tends in any way to discourage ambition in the large class of men upon whom we must rely.* The best we can do for an industrial organization and for everyone who enters it is to put recruits upon an actual rather than an artificial footing, allowing everyone to make his place in the organization in competition with everybody else. The company already alluded to has for two years made a practice of taking college men in as workmen at a living wage with no promises and no special privileges. The plan is working well and promises well."

A CARD INDEX SYSTEM FOR MOTIVE POWER DEPARTMENT LITERATURE.

To the Editor:

Many readers of your valued periodical are very busy men and can give but very little time toward thoroughly digesting the various articles which are published. Occasions are continually arising, where a remembrance of certain articles is of great value, especially where a similar design or process is contemplated, but unless a thorough index has been provided, under properly classified headings and subheadings, it is difficult to locate what is desired.

The annual index, published in the December number of the American Engineer, is very complete, listing each article under different alphabetical headings, but it is not so easy to locate an article, or series of articles on any subject, as would be the case if the index was made up under classified headings, suitable for a card index system. The writer has evolved such an index, and has frequently found the benefit of it, where discussions as to the practice of other railroads in regard to locomotives or machinery were being held and reference to various illustrations and articles bearing on the question at issue was desired. The saving in time was considerable and the sense of satisfaction at being able to readily locate the desired information was worth all it cost to attain.

From the arrangement of index headings and subheadings herewith submitted, you will notice that each general heading is numbered, and the various subheadings are indicated clearly by letter. This has been done so that a chief draftsman or other official, whose duty it is to care for the technical library of an office, can indicate by marking in pencil, both by number and letter, just under which general heading and subheading, any subject is to be indexed, and can then turn the journal over to a clerk for proper indexing. In order to do this he must have a

CARD INDEX HEADINGS AND SUBHEADINGS.

1—Locomotive Illustrations.
- 0-4-0 Class.
- 0-6-0 "
- 0-8-0 " —etc., following the American Locomotive Company Classification.

2—Locomotive Detail Illustrations and Descriptions.
- a—boilers.
- b—grate riggings.
- c—ash pans.
- d—front end arrangement.
- e—superheaters.
- f—boiler fittings.
- g—frames and details.
- h—running gear.
- i—cylinders and valves.
- j—valve gear.
- k—brakes.
- l—tenders.

3—Articles on Locomotive Design and Details.
- a—detail parts (designing of).
- b—tractive power and steaming capacity.
- c—compound locomotives.
- d—data on fuel (in relation to firebox size).
- e—boilers and boiler maintenance.
- f—cylinders and valves and valve gears.
- g—lubrication.
- h—comparative sizes of locomotives.

4—Articles on Locomotive Operation.
- a—energy and friction.
- b—road tests.
- c—big engines in service.
- d—boiler and flue troubles.
- e—allowances for wear.
- f—fuels, firing and water supply.
- g—train resistance and tonnage rating.
- h—brakes.
- i—cost of repairs.

5—Railway Track Data.

6—Railway Transportation.
- a—overloading and engine failures.
- b—adjusted tonnage rating.
- c—test runs.
- d—train operation and its cost.
- e—railroad statistics.

7—Car Illustrations.

8—Car Detail Data.
- a—wheels.
- b—truck and journal boxes.
- c—draft gear and couplers.
- d—center plates and side bearings.
- e—body details.
- f—brakes and details.

9—Steel Car Data.
- a—steel car illustrations.
- b—steel car development and construction data.

10—Cost Data of Cars.

11—Articles on Machinery.
- a—machinery illustrations.
- b—gas furnaces and gas engines.
- c—oil furnaces.
- d—forging machinery.
- e—hydraulic machinery.
- f—pneumatic tools, hoists, etc.
- g—air compressors.
- h—jigs, chucks, etc.
- i—general shop machinery equipment.

12—Motor Drive Applications.

13—Electrical Data
- a—power required to drive machinery.
- b—electrical fixtures, etc.
- c—systems of electric driving in shops.
- d—motors and generators.

14—Shop Operations, etc.
- a—shop machinery operation data.
- b—shop processes.
- c—machinery output
- d—feeds and drives.
- e—operation cost data.
- f—cutting speeds.
- g—lubrication of tools and machinery.

15—Tool Data.
- a—small tools.
- b—tool steels.

16—Shop Organization and Methods.
- a—shop organization.
- b—railroad shop management.
- c—apprenticeship systems.
- d—distribution of work.
- e—piece work, etc.
- f—round house and shop betterment.

17—Shop Layouts, etc.
- a—shop layouts.
- b—round house layouts.

18—Shop Buildings.
- a—shop buildings.
- b—coal and ash conveyors.
- c—ventilation.
- d—heating and lighting systems.
- e—track arrangement—locomotive shops
- f—shop equipment (cranes, etc.).
- g—fire risks.
- h—oil storage.

19—Power House Data.
- a—illustrations.
- b—steam engine power plant.
- c—gas engine power plant.
- d—terminal yard power plant.
- e—power factors in railroad shops.
- f—motors and generators.

20—General Machinery Data.
- a—working formula for machinery parts.
- b—data on materials of machinery and locomotives.
- c—data on materials of buildings.
- d—data on materials of cars.

21—Miscellaneous Articles, not included in above headings and subdivisions.

copy of the index arrangement before him, since, in some cases, the article will permit of being listed, and should be listed, under several general headings, as provided for by the subheadings.

Following out this system of indexing, in connection with the technical journals, will provide a working library which is always available. Without it more time would be consumed in searching for what is wanted, than could be devoted to it in many cases.

It is hardly necessary to call attention to the fact that, by proper provision on the index card, articles on the same subject from a number of different journals can be indexed, giving an instant possibility of comparison, if desired.

The index arrangement is submitted with the hope that others may find it advantageous to adopt, even though it does mean considerable work to compile it for several volumes at one time, since the advantages will be found to more than offset any labor involved.

Eng'r of Tests, P. & R. Ry. CHAS. A. BINGAMAN

THE RELATION BETWEEN THE MECHANICAL AND THE STORE DEPARTMENTS.*

By H. W. JACOBS.

The mechanical department's conception of an ideal store department is one that can fill immediately each and every requisition. To do this, the store department must carry a complete stock, the individual items of which are obtained either in the market or from the shops of the system. To accomplish this the store department must make use of its previous records, determining how much and what stock to carry, and must also be informed by the mechanical department concerning future demands, changes in engine locations and changes in standards. In addition, the mechanical department should have confidence:

(1) That the store department will take care of each and every call for material.

(2) That requisitions will be promptly filled.

(3) That requisitions will be filled correctly.

The stock in hand is the matter of greatest importance in every store house. The aim should be to have a small live stock with as little money as possible tied up and at the same time be able to fill requisitions as presented. The store department might come up to all requirements from the mechanical point of view and yet be inefficient from the standpoint of the owners of the road. Too much stock on hand is almost as much of a waste of money as not enough, not enough meaning loss of money through delays to engines and cars on the repair track, waiting for material to be bought or made, and too much meaning a loss of interest on money invested, deterioration in value on perishable articles, and danger of much of it becoming obsolete and worthless through change of standards.

The railroad that does not carry a full stock of material in the hands of an efficient store department is very short-sighted. I find that if the store department does not carry the necessary amount of stock each gang boss, roundhouse foreman, shop superintendent and master mechanic takes it upon himself to run his own little private store house for his needs, as he sees them. This means an innumerable number of duplications, no records or system and much time wasted hunting for material supposed to exist, but which either never did exist or has been lost. An efficient store department can reduce the quantity of stock by taking complete charge of it, keeping complete records of its location and distributing it geographically to correspond with the class distribution of engines. The mechanical department can further aid the store department to reduce the quantity of stock required, and also the value of it, by standardizing all material to the greatest possible extent.

Standardization reduces quantity. As an example, if of one hundred classes of engines the main rod key is different for each class, the store department must carry at least three hundred keys to protect every engine; if, however, these keys were standardized so that one style of key would do for every engine, then a stock of fifty keys would be ample to protect all of the one hundred classes. Standardization reduces cost, as large quantities of duplicate pieces are ordered at one time and consequently the cost of manufacture per piece can be materially decreased. There is little to be gained in making standard parts unless these parts are to be made in quantities and distributed by an efficient store system.

Standardization also permits of going into the open market for standard parts. This is more the province of the purchasing department than the store department, although the store and mechanical departments are both concerned in the value of their material.

I have said the mechanical department will not order anything unless they need it. This statement should be modified, for unless close watch is kept of the foremen making requisitions they will continually order from two to three times what is needed in their great caution to protect themselves. It is, however, hardly in the province of the store department to dictate as to what the foremen shall order unless they are ordering material which is not standard.

* Extracts from a paper presented before the Railway Storekeepers' Association.

The mechanical department should aid the storehouse to have a competent person pass on all requisitions and see that only the required amount and class of material is ordered. At a certain point, where shops are located, which I have in mind, this official is known as the material supervisor and the results of his work have been a decided decrease in the amount of material ordered for engines being repaired.

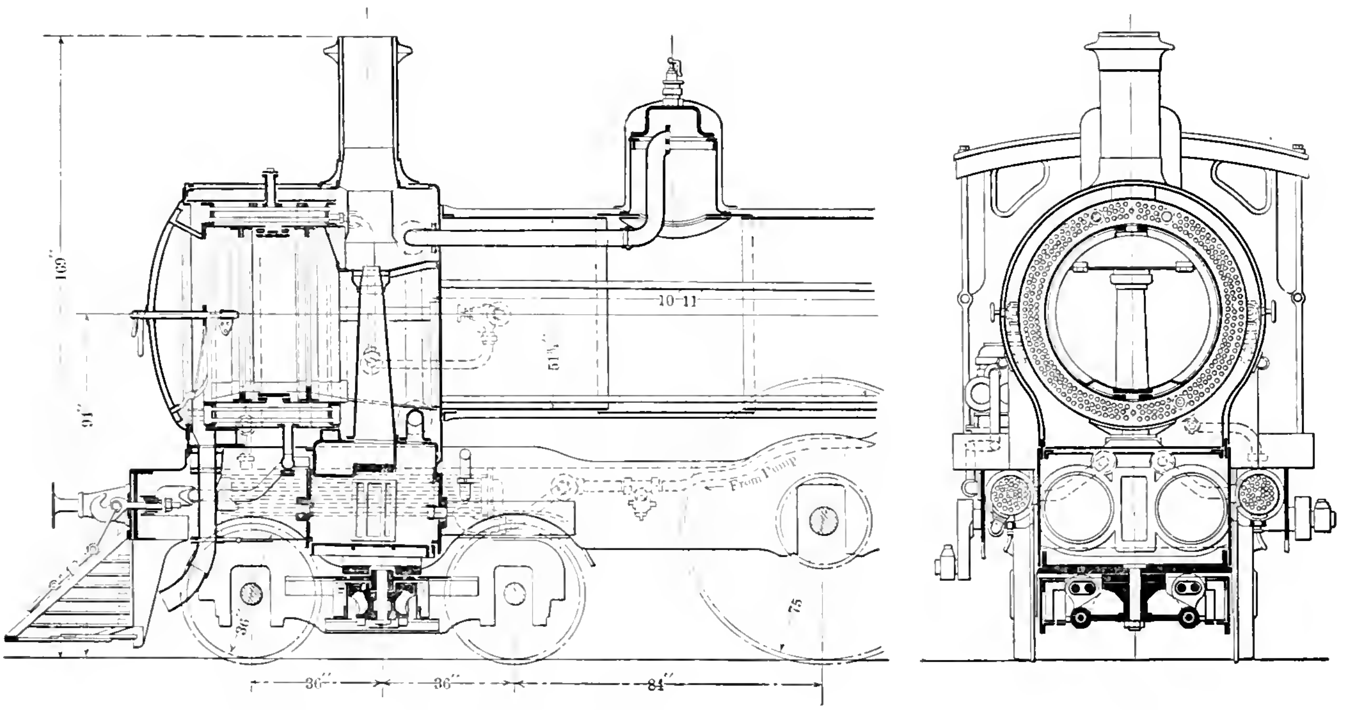
I have said that the ideal storehouse should fill every requisition when presented. This means that everything should be carried in stock and all requisitions filled from stock. I would have the store department return to the maker every requisition it cannot fill in three days, or a reasonable length of time, and with the return should be a notice as to when it was expected this material would be in stock.

The maker of the requisition then makes his plans to meet existing conditions. If there is no chance to get the material until some time long after he needs it, he will make arrangements to use something else. If, on the other hand, the material is expected in stock soon enough to meet his needs he will send another requisition, or return the first one at a later date.

the lower header having an opening to the atmosphere. The feed water circulates around the outside of the tubes.

On leaving the pump the water traverses in succession two other heaters, one on either side of the smoke box. The one on the right is divided into two compartments by a partition, so that the water traverses twice the length of the heater in passing through. It then goes to the left heater in which there is no dividing partition. These two heaters are heated by part of the exhaust steam from the cylinders. From these the water passes to the larger heater in the front end, which consists of an annular chamber containing 265 tubes 1 in. diameter and 18 in. long, arranged in three concentric rings and heated by the exhaust gases passing through the tubes. The total section of the heater tubes, which is but little larger than the section of the smoke-stack, is entirely utilized, and their position in reference to the fire tubes assures a perfect separation of the escape gases to the interior of all of them. From this heater the water passes to the boiler through the usual check valves.

Tests which have been made with this heater show that feed water at 68 degs. F. in the tender is heated up to 80 degs. in the



TREVITHICK FEED WATER HEATER FITTED TO 4-4-0 TYPE LOCOMOTIVE, EGYPTIAN STATE RAILWAYS.

TREVITHICK FEED WATER HEATER.

There was exhibited at the Milan Exposition an eight-wheel locomotive owned by the Egyptian State Railways, which was equipped with a feed water heater designed by Mr. F. H. Trevithick, locomotive, car and wagon superintendent. This locomotive has cylinders approximately 17¾ x 26 in.; 75 in. drivers and carries 196 lbs. steam pressure. Its total weight is 23,480 lbs.

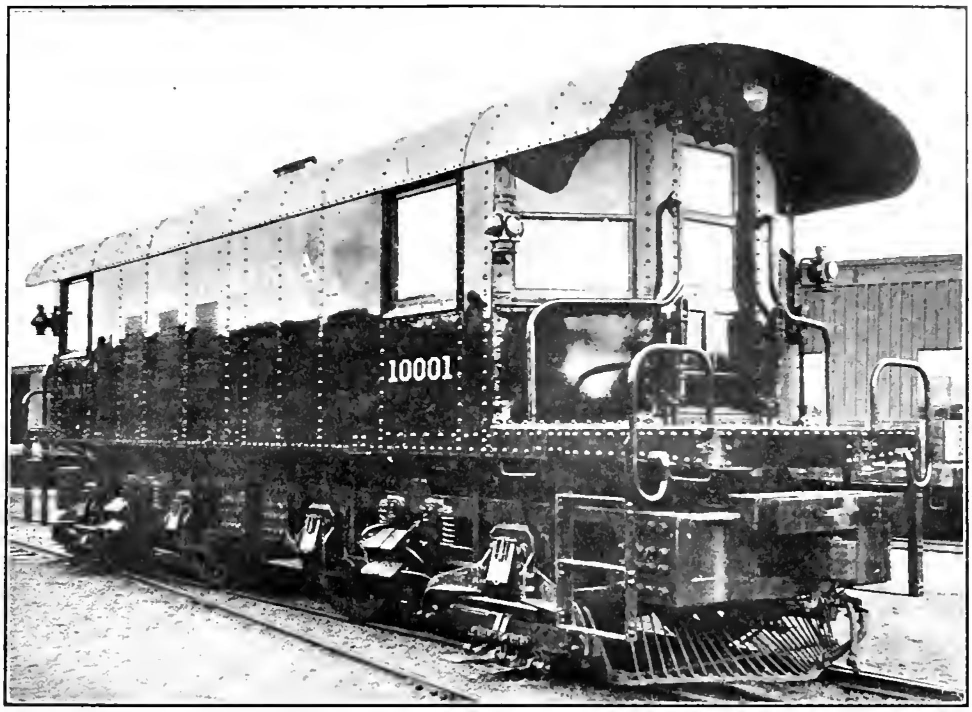
The accompanying illustration, showing part of the locomotive and feed water heater, as well as the following description of its operation and construction, is taken from the *Revue Generale des Chemin de Fer,* in the August and September issues of which will be found a very complete description of all the locomotives and railway material exhibited at the Exposition.

The feed water is drawn from the tender and forced into the boiler by means of a horizontal duplex pump located on the right side just ahead of the cab. This pump takes steam at boiler pressure and delivers its exhaust into the first section of the feed water heater, which is located on the suction side of the pump. This first heater is vertical and contains nineteen ⅝ in. tubes, which are connected to headers at each end, the upper header being connected to the exhaust pipe from the pump and

first heater, raised to 159 degs. in the second heater, to 193 degs. in the third heater and leaves the smoke box heater at about 270 degs. F. The estimated saving in fuel is about 16 per cent.

A brief description of this feed water heater was given in a paper by Mr. Max Toltz, presented before the New York Railroad Club at the September, 1907, meeting. The description there given was taken from a German paper, and gives somewhat different temperatures in the different sections of the heater. It also states that the saving in coal is over 20 per cent. In discussing this re-heater, the author of the paper suggested that the third section of the heater, where, according to the figures there given, the water is raised from 180 degs. to 230 degs. F., should have trays instead of pipes, upon which all sediment and other matter could be deposited and thus the heater could be made to act as a feed water purifier. It would be necessary in that case to reduce the velocity of flow considerably through this heater in order to give the precipitate a chance to settle upon the trays. These trays could be arranged for easy removal and cleaning.

Block Signals on Union Pacific Railroad.—This road has in operation 496 miles of single and 244 miles of double track equipped with electric automatic block signals.



EXPERIMENTAL ELECTRIC LOCOMOTIVE, PENNSYLVANIA RAILROAD.

ELECTRIC LOCOMOTIVES FOR THE PENNSYLVANIA RAILROAD.

With a view of determining the type best adapted to pulling its heavy passenger trains through the New York tunnels, the Pennsylvania Railroad has in progress a series of experiments upon electric locomotives on its West Jersey and Seashore Division and the Long Island Railroad.

Of the direct current locomotives now undergoing tests, one is equipped with four 350 horse-power geared motors and the other with four gearless motors. The locomotive with gearless motors has one of its trucks equipped with two 320 horse-power motors supported by springs from the main journals and wholly independent of the truck frame, while the other truck has two 300 horse-power motors rigidly fastened to the truck frames. This arrangement will demonstrate the advantages of the two methods of motor suspension under the same conditions of service.

In exterior appearance the two locomotives are almost identical. The trucks are of the four wheel type, having frames placed outside the wheels, with pedestal boxes and adjustable wedges similar to those used in locomotive practice.

On account of their short wheel base the trucks have a tendency to tilt in operation, and thereby shift a portion of the effective load from one pair of wheels to the other. By an ingenious automatic switching mechanism the power delivered by the motor on the heavily loaded axle is increased and the power delivered by the motor on the lightly loaded axles diminished, in proportion to the difference in axle loads. By this expedient the pulling power of the locomotive is said to be increased 25 per cent.

The outer-end casting of each truck carries the coupler, draft spring and buffer arrangement, so that strains caused by pushings, pulling and buffing are taken directly by the truck frames and do not come upon the underframe of the cab, except as they are transmitted between bolsters through the center sill. In order to allow sufficient lateral play when the locomotive is coupled to a long passenger car with considerable overhang, the coupler head has a free movement of 15 inches on either side of the center line of the truck. To facilitate coupling and uncoupling on curves, the coupler can be swung sideways and its uncoupling pin raised by means of levers at the end of the cab, which can be operated from the platform.

The driving wheels are 56 in. in diameter with removable tires secured by retaining rings. They are carried on axles 8 in. in diameter at the center, provided with 6 x 11 in. journals.

The spring rigging is of the locomotive type, with semi-elliptical springs over the journal boxes, and equalizers between the springs. To prevent teetering the equalizer beam is not provided with a fixed fulcrum, but instead supports two nests of helical springs, which in turn help to support the truck frame.

The collector shoes are attached to the four end journal boxes, and are made of two castings forming a spring hinge, with one wing lying in a horizontal plane, and sliding on top of the third rail. The current passes from the third rail through the collector shoes and the heavy cables to the fuse boxes located near the shoes.

The cab is entirely of metal; its underframe is composed of a center sill, built of two 10-inch channels, side sills of 7 x 3½ in. angles, plate bolsters and end sills. Within the cab the apparatus is distributed along the sides, leaving a passage way through the middle.

The locomotive control mechanism is of the Westinghouse electro-pneumatic type, in which the switches are operated by air pressure. This pressure is controlled by valves actuated by a control magnet on a 14 volt circuit, which circuit in turn is controlled by the master controller. The control mechanism is in duplicate and is placed in diagonally opposite corners of the cab. The current for operating the control magnets is obtained from storage batteries, of which there are two sets, one for use while the other is being charged. These batteries are charged by placing them in series with the motor of the air compressor.

The equipment includes hand, straight air, automatic and high speed brakes and the locomotives have the following general dimensions:

Diameter of driving wheels	56 in.
Axles	8 in.
Journals	6 x 11 in.
Length over couplers	37 ft. 10½ in.
Wheel base of truck	8 ft. 6 in.
Total wheel base	26 ft. 1 in.
Extreme width of cab	10 ft. 1¾ in.
Extreme height	14 ft. 5⅜ in.
Weight (with geared motors)	175,100 lbs.
Weight (with gearless motors)	195,200 lbs.

Master Car Builders' Letter Ballot.—Of the 108 recommendations submitted to letter ballot, all but the following six were adopted: No. 15, Brakebeam No. 1; No. 16, Brakebeam No. 2; No. 25, Tests of brake beams; No. 87, Omission of column bolt washers; Nos. 89 and 90, Tank car specifications, including provisions for stenciling light weight and capacity.

VIEW OF COS COB POWER HOUSE SHOWING COAL DOCK AND CONVEYOR.

HEAVY ELECTRIC TRACTION ON THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD.*

POWER STATION.

The power house at Cos Cob furnishes single-phase current for the operation of electric trains over the New Haven Road and is also designed to deliver three-phase current to the Port Morris power house of the New York Central to compensate for the energy required to operate the New Haven trains over the lines of the New York Central System.

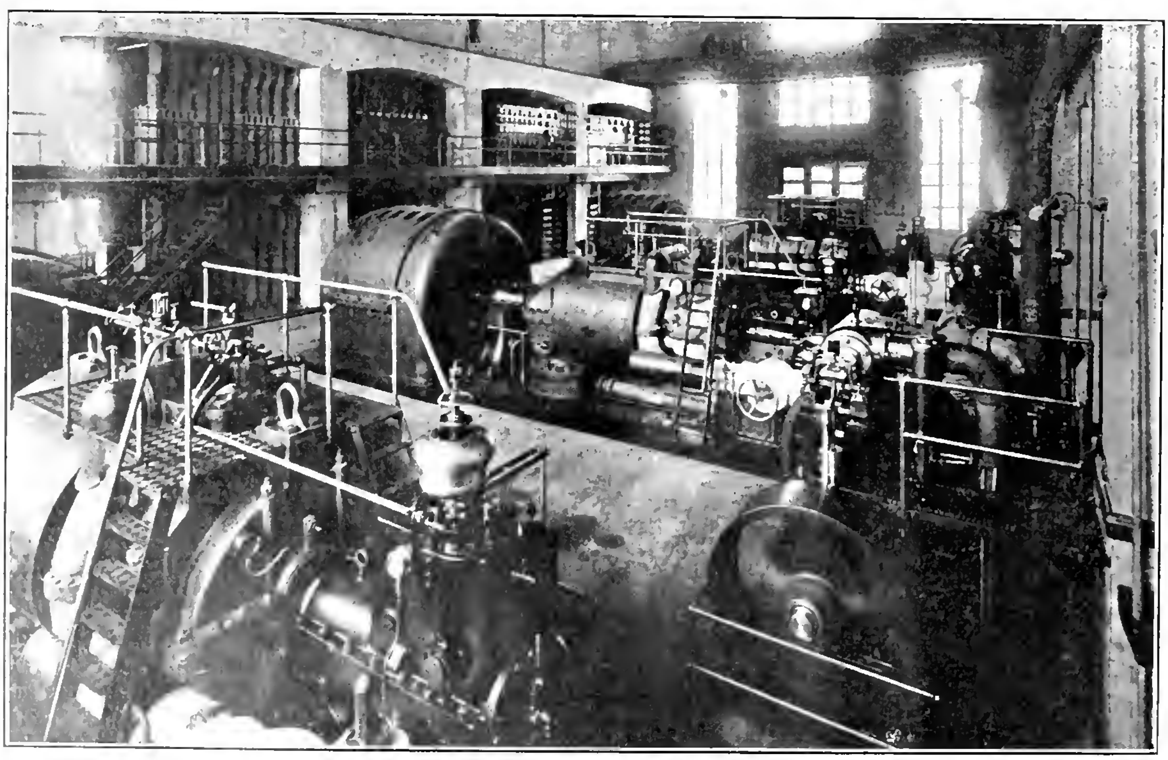
Building.—The power house is located adjacent to the main line of the railroad and on the bank of the Mianus River at a point on the river about one mile from Long Island Sound. The location is such that coal can be delivered either by water or rail, and an unlimited amount of salt water for condensing purposes is available from the Mianus River. By the erection of a dam in this river at a point about a mile up-stream from the power house an abundant supply of exceptionally pure boiler feed water is also readily obtained.

The general style of architecture of the power house building is Spanish Mission: the walls being constructed of plain-faced concrete blocks, the color of which forms a pleasing contrast with the red Spanish tile roof.

The entire area of the site selected was practically solid rock, with but a few inches of earth above it, and necessitated blasting the excavation for the basement and the condenser intake and discharge flumes.

The material excavated was a gneiss rock which proved excellent for concrete aggregate. The building walls, below the water-table, and the machinery foundations are monolithic concrete. The water-table and the walls above it, including the window arches and coping, are of concrete blocks. The interior columns in the boiler room are of structural steel, but all other columns required in the building are of concrete blocks. The steel roof trusses over the turbine room are supported on concrete block pilasters formed in the building walls, while over the boiler room they are carried by the pilastered building walls and by the interior steel columns, which also support the boilers, the mechanical draft equipment and the stack. The front of the switchboard gallery, at the south end of the turbine room, is carried on concrete block columns which also support a reinforced concrete girder forming one of the crane runways. The other crane runway is formed by another reinforced concrete girder built into the partition wall between the turbine room and boiler room, and is supported upon pilasters formed in this wall. The column footings below the turbine room and boiler room floors are of monolithic concrete.

* For general article giving the causes leading to this electrification and the reasons for adopting the single phase alternating current system, see page 362, September issue, and for description of the overhead structure and electric locomotives see page 396, October issue of this Journal.



VIEW IN TURBINE ROOM, COS COB POWER HOUSE—NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

The basement floor is of concrete, laid upon the foundation rock. All other floors in the building are of reinforced concrete; and the roof, which has a pitch of $4\frac{1}{2}$ in. per foot, is of reinforced cinder concrete finished on the exterior with Ludowici tile.

A monitor, provided with windows for light and ventilation, extends lengthwise over the boiler room.

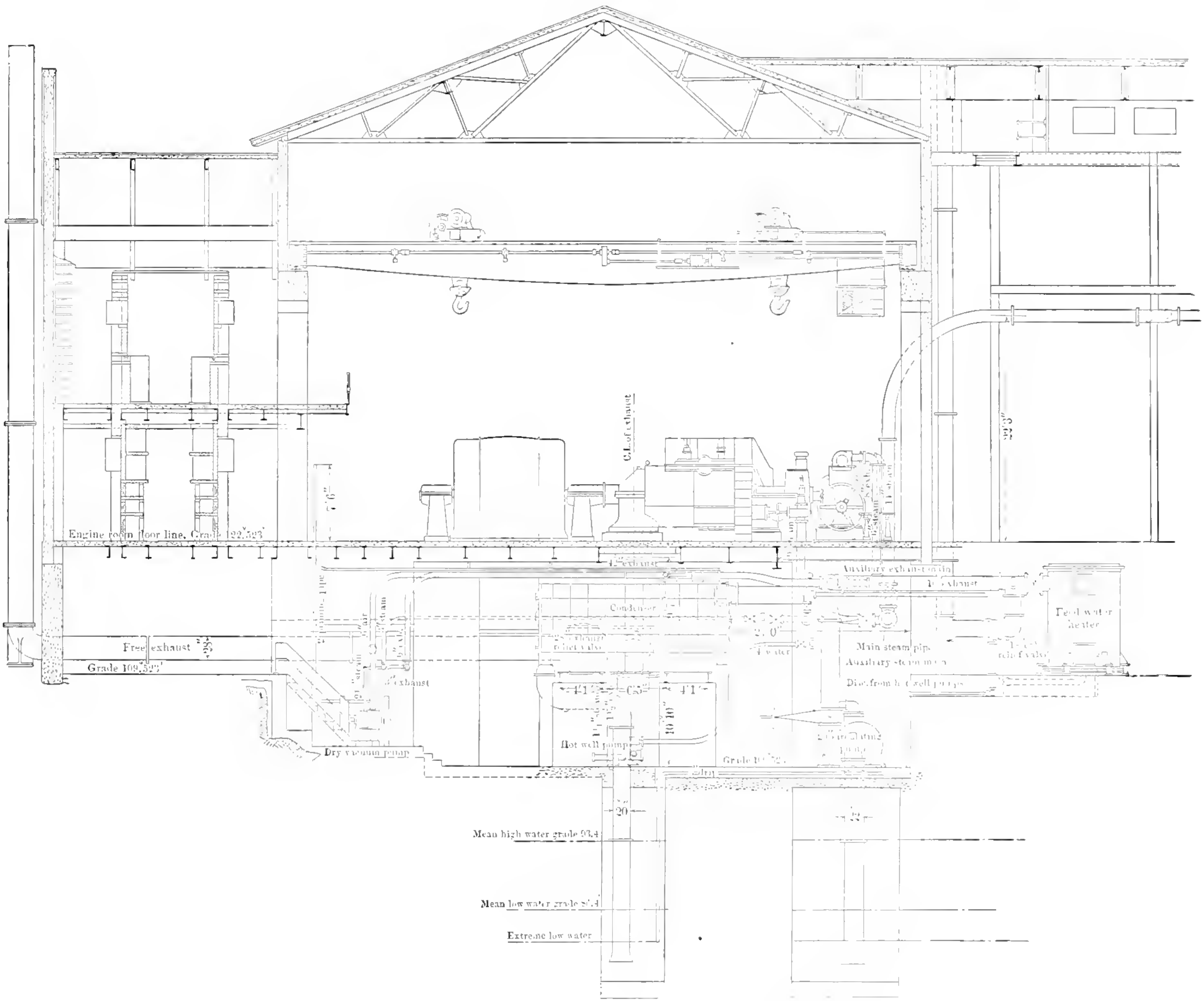
A self-supporting steel stack 13 ft. 6 in. in diameter extending to a height of 100 ft. from the boiler room floor, is carried by the steel columns which support the fan room floor, leaving the space below, on the boiler room floor, entirely clear.

The building is exceptionally well lighted by large windows glazed with wire glass set in cast iron sash.

flow Parsons steam turbines direct-connected to single-phase Westinghouse generators. Provision has been made for the installation of a fourth unit of corresponding size. The turbines are rated at 4,500 brake horse-power each and the generators at 3,000 kw. each, at 80 per cent. power factor.

As the requirements necessitated the generation of three-phase current for delivery to the New York Central system as well as single-phase current for the operation of the electric locomotives over the New Haven Railroad, the generators are wound for three-phase current but arranged for the delivery of both three-phase and single-phase current.

The turbines are operated at 1,500 revolutions per minute by steam at 200 lbs. pressure and 100 deg. superheat. The continu-



SECTION THROUGH TURBINE ROOM, COS COB POWER HOUSE—N. Y., N. H. & H. R. R.

The turbine room is 60 ft. wide by 112 ft. long, and the switchboard occupies a space, next to the turbine room, which is 25 ft. wide by 110 ft. long. The boiler room is 160 ft. long and 110 ft. wide.

The reduced head room needed for horizontal turbine equipment is shown by the fact that the distance from the floor to the top of the crane runway rail is but 27 ft. 2 inches, and the height from the turbine room floor to the bottom of the roof trusses is but 39 ft. 2 inches. The interior walls of the turbine room are finished with a wainscoting of Faience tile six feet in height.

Turbo-Generators.—The initial generating equipment of the power house consists of the three multiple expansion parallel

ous overload capacity of the units is 50 per cent., and momentary overloads of 100 per cent. can be taken care of when operating condensing.

The turbines are equipped with the latest accessories in the way of automatic safety stops, water packed glands for the turbine shaft, and adjustable water-cooled bearings equipped with a continuous circulation oiling system.

The generators are entirely enclosed by a casing into which air is drawn through suitable ducts from a fresh air chamber under the switchboard gallery, and from which the air is discharged through other ducts into the basement. This system of generator ventilation renders the operation of the generators practically noiseless.

The excitation of the generator fields is provided for by two 125 kw. direct current generators, direct connected to Westinghouse engines; and one motor driven exciter.

Condensers.—A separate condensing outfit is provided for each turbine consisting of an Alberger three-phase counter-current surface condenser, a two-stage dry air pump, a centrifugal circulating pump direct-connected to a Westinghouse engine, and a Monitor hot well pump, the speed of which is automatically controlled by a float.

Condensing water for all the condensers is furnished by a single flume which is constructed of timber having a lining of creosoted lumber, from the intake at the face of the dock to the shore line, and of concrete for the remainder of its length to and under the generator room. A discharge flume of similar construction parallels the intake flume under the turbine room, and then diverging from it discharges the condensing water into the river. Each condenser is installed directly beneath the corresponding turbine, and over the discharge flume, while the circulating pumps are located over the intake flume, thus making all the connections as short as possible.

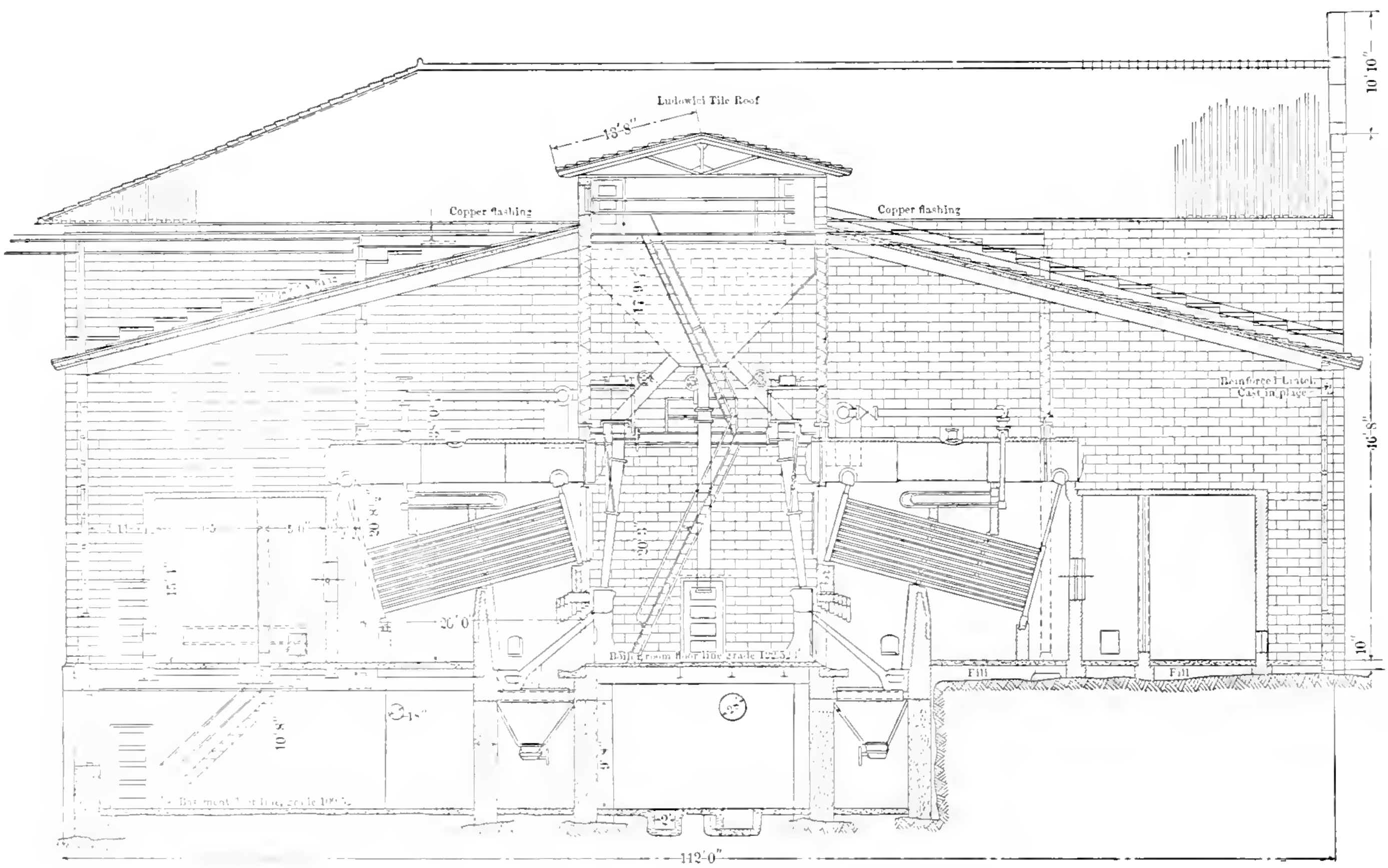
fourth turbo-generator unit when it is installed. These boilers are equipped with Roney mechanical stockers and Babcock & Wilcox superheaters and deliver steam at 200 pounds gauge pressure and 125 deg. superheat.

A novel feature of the boiler settings is the installation of an external steel casing entirely enclosing the brickwork, thus rendering the settings impervious to air leaks.

Economizers.—Three Green fuel economizers are provided and the boiler flues leading to the economizers are arranged with by-passes so that one or all of the economizers can be cut out, and the flue gases from either two or four batteries may be passed through either one of two of the economizers, thus adapting the economizer installation to the changing demand upon the boilers.

The economizers are enclosed by means of metal sectional covering insulated with prepared asbestos blocks.

Feed Water System.—Under ordinary conditions the boiler feed water is delivered from the pump house at Mianus through a 10-inch main to a concrete reservoir of 600,000 gallons capacity situated just outside the power house. From this reservoir the



SECTION THROUGH BOILER ROOM, COS COB POWER HOUSE—N. Y., N. H. & H. R. R.

The pipes leading from the condenser to the discharge flume have a submerged discharge, thus decreasing the head under which the circulating pumps work.

To prevent the rapid deterioration of the brass condenser tubes by the galvanic action which usually occurs where salt water is employed for condensing purposes and which is often aggravated by stray currents passing through tne water pipes into the station and from thence to the condensers and out through the pipes leading into the intake and discharge flumes, a motor generator set has been installed and provided with suitable controlling apparatus for maintaining in each condenser a counter electromotive force slightly in excess of the electromotive force due to the galvanic action and the stray currents.

Boilers.—The initial installation consists of 12 525 h.p. Babcock & Wilcox water-tube boilers set in batteries of two boilers each, and arranged with 8 boilers on one side and 4 boilers on the other side of the boiler room, separated by a 21 ft. firing floor. Provision is made for 4 additional boilers to take care of the

make-up water flows by gravity to two 13,000-gallon feed water tanks located in the boiler room basement. These tanks also receive the discharge from the hot well pumps. The water is then drawn from these tanks by the feed pumps and delivered through the feed water heaters and the economizers into the boilers.

An auxiliary source of feed water supply is provided by a connection to the mains of the Greenwich Water Co.

The feed pumps, three in number, are of the compound, direct connected, duplex, outside packed, plunger type.

Provision is made for connecting either source of feed water supply direct to the suction side of the feed water pumps, and also for by-passing the feed water heater or the economizers. An emergency feed water supply system is also provided, consisting of two Hancock inspirators, taking water from either source of supply and delivering it through an independent line to the boilers.

The pumping equipment at Mianus comprises two single act-

ing vertical triplex plunger pumps, geared to Westinghouse three-phase motors. One of these is of sufficient capacity to meet the requirements of the plant running non-condensing, and the other, to supply all the fresh water needed when running condensing. These pumps are operated by current obtained from the power house.

Induced Draft System.—After leaving the economizers, the flue gases pass through sheet iron flues to the fan chamber over the center of the boiler room. Here, four 14 ft. fans, direct connected to horizontal high speed engines, deliver the flue gases to the stack, which is only of sufficient height to carry the gases away from the building. The speed of the fans is adjusted to the demand on the boiler by automatic regulating valves controlling the fan engines.

Coal Handling.—All coal received by water is unloaded from the barges by a steel derrick operating a clam shell bucket and is delivered into a hopper of fifteen tons capacity at a height of 55 ft. above the dock. This bucket is operated by an engine on the dock, supplied with steam from the power house. From this hopper the coal is fed by gravity into a coal crusher and from the crusher it drops into steel cars where it is weighed. The cars are then drawn by cable up an inclined single-track railway of 13 per cent. grade and into the boiler room through an opening near the roof. This track is supported upon structural steel towers, and is designed so that two cars can be operated upon it, passing each other through an automatic turnout at the center. The cars discharge the coal into a hopper, from which it is delivered into two flight conveyors, extending the length of the boiler room. Openings in the bottom of the flight conveyors discharge the coal into sprouts leading to the stoker hoppers of the boilers. The capacity of the flight conveyors is in excess of the amount of coal required to operate the boilers, and the surplus coal is discharged at the further end of the boiler room into a concrete storage bin below the boiler room floor.

Coal received by rail is dumped from the car directly into a chute leading to this same storage bin. When the boilers are to be supplied from this source the coal is discharged from the bin by gravity into a coal crusher, and from thence into a bucket conveyor located in a tunnel underneath the bin, by which it is delivered to the flight conveyors above the boilers, and thence through the chutes to the stoker hoppers.

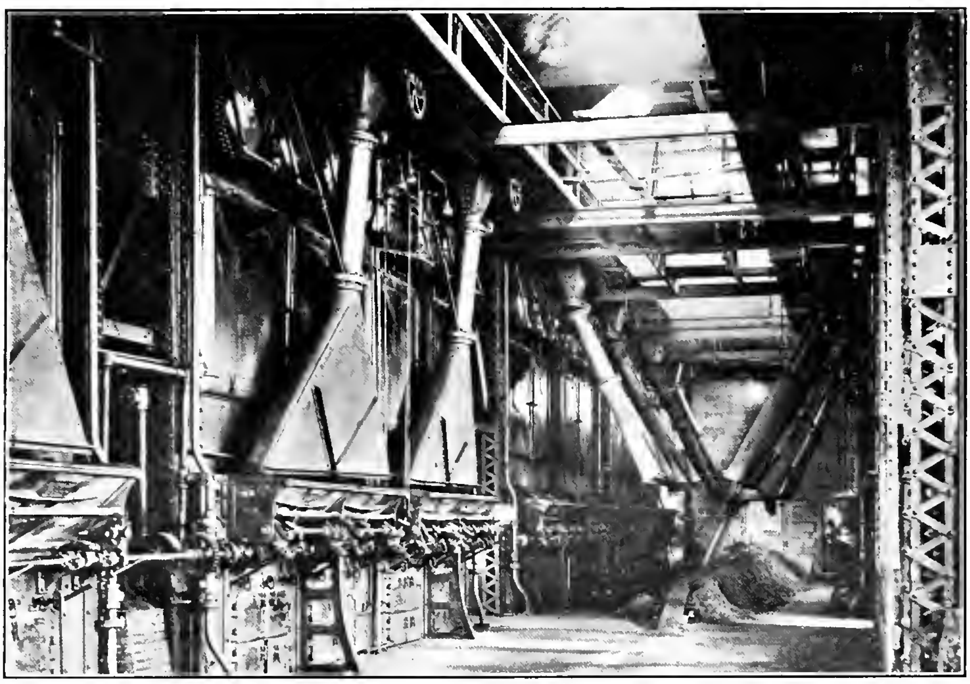
The cable railway and the flight and bucket conveyor are operated by three-phase induction motors, taking current from the "Station Service" line.

The ashes are disposed of by gravity from the dumping grates of the stokers into chutes leading to narrow-gauge cars in the basement, by which they are at present carried to the low ground in the neighborhood of the power house, and used for filling.

Piping.—A steam main is carried over the boilers on each side of the boiler house, each of the two mains crossing over to the opposite side at the center of the boiler room. Provision is made for cross-connecting these two mains. From the boiler room the mains extend through the partition wall into the turbine room, thence downward into the basement connecting to a header under the floor. From this header connections are made to each turbine. In addition to the throttle valves and the automatic stop valves, shut-off valves are provided for each turbine under the boiler room floor. These valves are controlled by hand-wheels mounted on stands in the turbine room. A separate steam main is provided for the steam driven auxiliaries, which are all designed to use superheated steam. Steel pipe, with extra-heavy welded flanged joints, is used for all high pressure steam lines, contraction and expansion being provided for by the use of long radius bends.

An exhaust line leads from each turbine directly down to its condenser and is connected by an automatic relief valve to an individual outboard exhaust line, which passes through the turbine room basement to the outside of the building and thence to a point above the roof.

The piping from the pumps to the feed water heaters and economizers is of cast iron, while that from the economizers to the boilers, with the exception of a cast iron header below the floor, is of brass.



INTERIOR OF BOILER ROOM, COS COB POWER HOUSE.

A closed feed water heater containing 2,000 sq. ft. of surface and utilizing the exhaust from the steam driven auxiliaries is provided.

Oiling System.—A continuous circulation oiling system for the turbine and generator bearings is installed. The oil is elevated by a small steam pump into a tank situated in the fan room and flows from this tank by gravity to the various bearings. After passing through the bearings, it is discharged into a filter, from which the filtered oil passes to a receiving tank in the turbine room basement, to which the suction of the oil pump is connected.

Taps are placed in this line at convenient points for filling the oil cups on the auxiliary engines and pumps.

Electrical Distribution.—The main cables from each generator are run in the air chamber under the turbine room floor, up to the switchboard gallery and thence through selector oil circuit breakers down to the high tension buses under the switchboard

gallery. These circuit brakers are electrically interlocked so that the buses cannot be paralleled.

The two high tension buses, with their accompanying switching equipment are interchangeable and are arranged so that each can be used separately: one suppling three-phase current to the Port Morris feeders, and the other supplying principally single-phase current for propulsion. Each bus is further divided by knife switches into three sections: each end section containing generator leads and propulsion feeders, and the center section containing the Port Morris feeders, so that in an emergency a still further subdivision can be effected.

When a bus section, or the entire bus, is used for supplying single-phase propulsion current, one leg is grounded directly to the track rails of the right of way through suitable switches; another leg supplies the outgoing feeders, which are run in duplicate, connecting directly to the trolley and which forms the complete single-phase circuit: the third leg of this bus is also connected to a feeder which is carried along the right of way for the purpose of supplying power for local purposes, and completing the three-phase circuit along the line.

Each leg of the high tension bus, consisting of two 3 in. x 1/4 in. copper bars, is enclosed in a separate masonry compartment composed of pressed brick and soapstone and is supported on porcelain pillars and bushings projecting from the side wall of the compartment, the bushings providing for cable connections

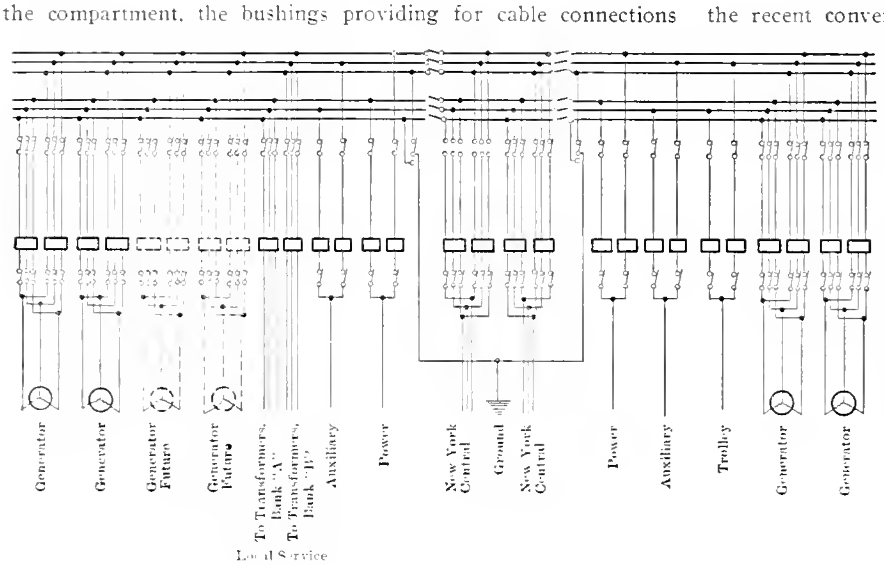


DIAGRAM OF HIGH TENSION CONNECTIONS, COS COB POWER HOUSE.

to the bus. Removable glass doors are provided in the bus compartments at small openings opposite all connections and supports. The connections between the bus bars and the circuit breakers consist of insulated cable and are carried up in separate brick septums on the back of the bus bar and oil circuit breaker structure. Each oil circuit breaker can be disconnected from the bus and circuit by hook type knife switches located on the rear of the structure.

The feeder cables pass along the top of the circuit breaker structure, thence to choke coils in the arrester gallery and through special windows, to the line. Each feeder is protected by a lightning arrester of the Westinghouse Electric & Mfg. Co.'s low equivalent type, with fuses.

For normal operation of this station one set of buses will supply the three-phase feeders leading to Port Morris, and the other set the single-phase propulsion feeders and the local three-phase circuits.

The voltage of each high tension bus is maintained constant by a Tirrill regulator, controlling the exciter field circuits.

Switchboard.—The main switchboard is made up of marble slabs carrying Westinghouse instruments and switching apparatus. It contains four panels for the operation of the generators, three panels for the control of the exciters, two panels for the Tirrill regulators, one load panel, one inclined station panel for the synchroscope, and A. C. voltmeters, and five panels for the apparatus controlling the outgoing feeder system and the local high tension circuits.

Each generator panel is equipped with instruments indicating the current per phase, the power factor, the indicated watts, and the field current. Receptables are also provided on each generator panel for making connections with the synchroscope and the voltmeters on the inclined panel. This panel contains the main field switch and rheostat handwheel, together with an electric governor controller for changing the speed of the generators from the switchboard gallery for the purpose of synchronizing, when it is desired to throw two or more generators in parallel. The oil circuit breakers between the generator and the buses are also electrically controlled from these panels. Totalizing wattmeters are placed in the bus sections in such a way as to register the total load of the generators or of any group of feeders.

Each feeder is equipped with an ammeter, overload relay and controllers for its oil circuit breakers. Colored lights on the switchboard indicate the position of the circuit breakers.

For supplying power to the various motors throughout the station, duplicate sets of two transformers each are used. They are "T" connected and supply three-phase current at 440 volts.

For the control of the station circuits, a local service switchboard is installed.

THE VALUE OF A BRICK ARCH.

A paper which was presented by Mr. G. W. Bennett before the recent convention of the International Master Boiler Makers' Association gave the results of some tests which were made on a wide firebox engine to ascertain the efficiency of the brick arch and arch tubes.

The boiler of this locomotive had a firebox 105 in. long and 75 1/4 in. wide. It contained 458 2-in. tubes 15 ft. 6 in. long and carried a steam pressure of 200 lbs. The firebox was equipped with four 3-in. water tubes for supporting the arch. The test showed that with the brick arch and water tubes in place the equivalent evaporation per dry pound of coal showed an increase of 14.9 per cent. over that obtained without the arch or tubes. There was a gain of 9.3 per cent. with the arrangement with the water tubes, but without the arch in service. The coal nred per sq. ft. of grate area per hour showed a decrease of 14.7 per cent. and 7.8 per cent. under the same conditions.

The tests were very carefully made and the boiler pressure was maintained constant. Six runs were made in each case, three with a partially closed throttle and three with a wide open throttle. The results given are an average of all the runs.

TEST OF 7500 K. W. STEAM TURBINE.

An eight-hour economy test was made, September 1, on a 7,500 k. w. Westinghouse-Parsons steam turbine at the Waterside Station of the New York Edison Company. The turbine unit is of the standard Westinghouse construction throughout and has a maximum rated capacity of 11,250 k. w. It was built to operate on 175 lbs. steam pressure, 28 in. vacuum and 100° superheat. Under these conditions the turbine was guaranteed to have a minimum steam consumption of 15.9 lbs. per k. w. hour with a normal speed of 750 r. p. m. The electrical efficiency of the generator was guaranteed to be 97.8 per cent., exclusive of friction and windage.

The results of the tests, calculated for the conditions as actually run, were as follows:

Duration of test	8 hours
Average steam pressure at throttle	177.5 lbs.
Average superheat at throttle	95.74 degrees
Average vacuum	27.31 in.
Average load on generator	9,830.48 k. w.
Average steam consumption	15.15 lbs.

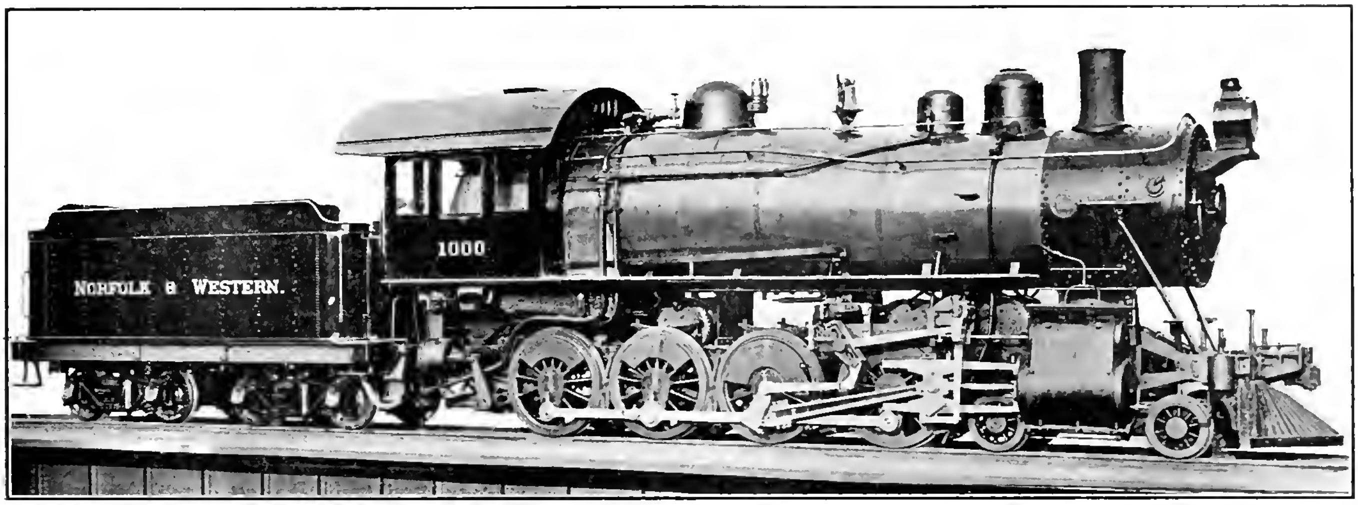
It will be noted that the conditions under which the tests were run were somewhat different from those under which the guarantee was made, and when corrections are made for these differences it shows that the water rate for the turbine was 14.85 lbs. per k. w. hour, or 1.05 lbs. less than the guaranteed rate.

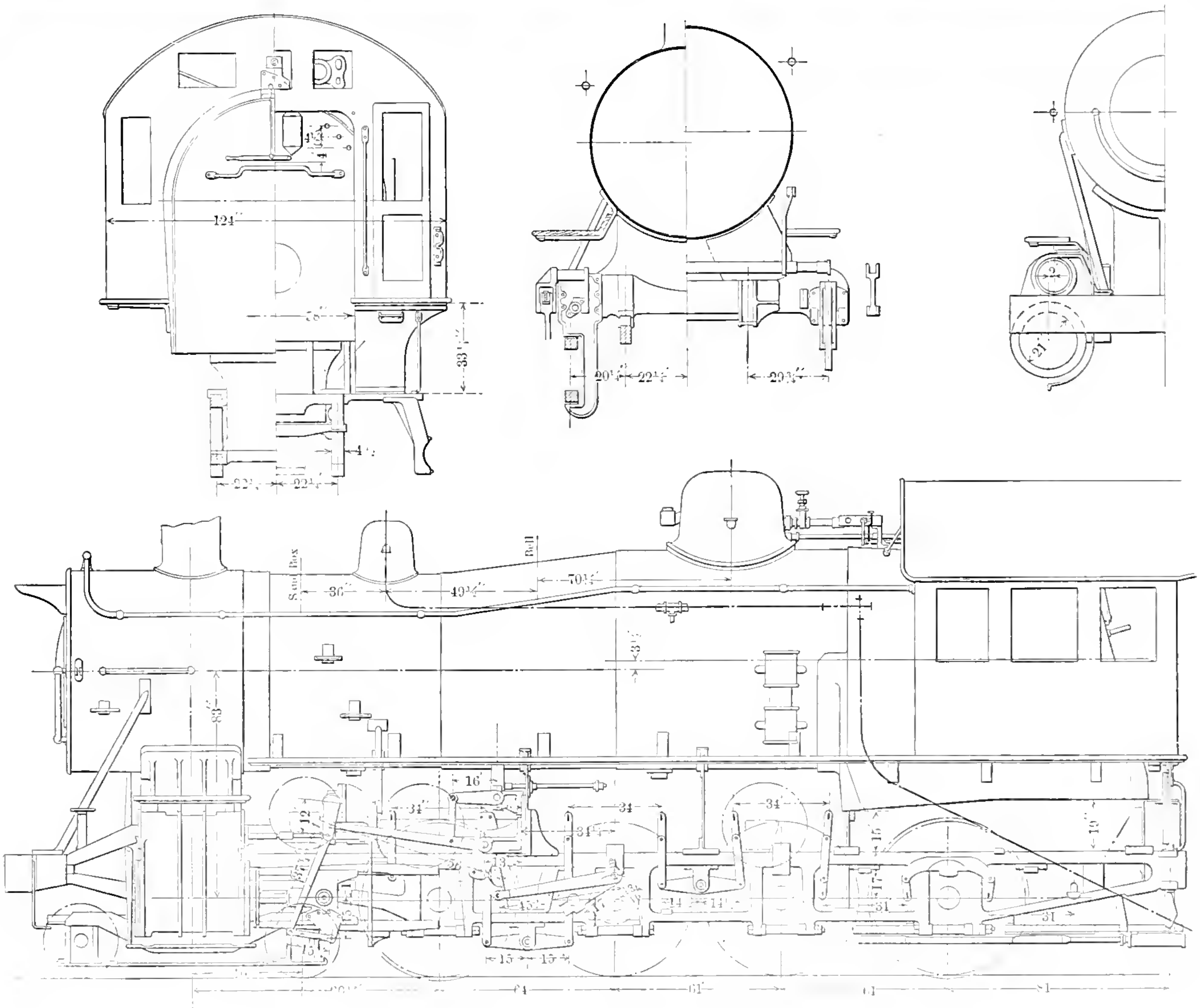
TWELVE-WHEEL FREIGHT LOCOMOTIVE.

NORFOLK & WESTERN RAILWAY.

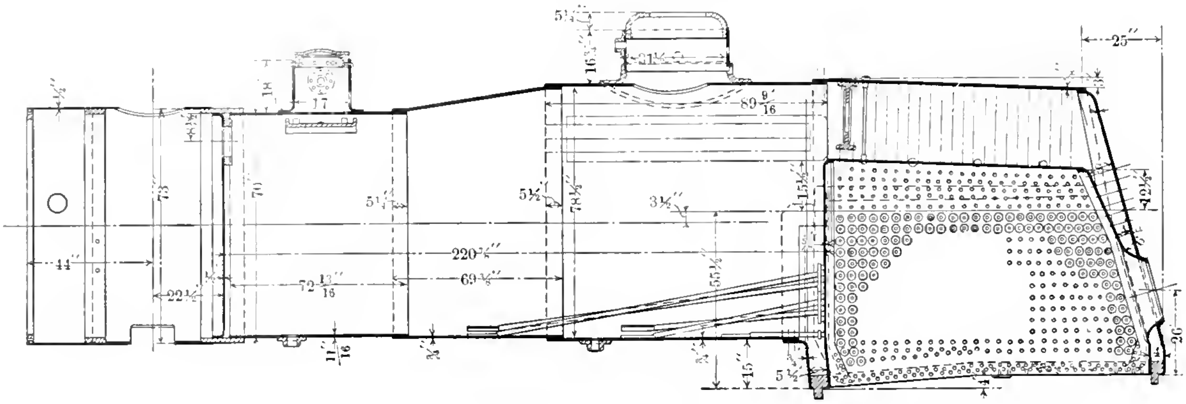
The Baldwin Locomotive Works has recently delivered fifty 4-8-0 type locomotives to the Norfolk & Western Railway, which are in general very similar to an order built last year for the same road. The most important change made in the design is the substitution of the Walschaert for the Stephenson valve gear The principal details, aside from the valve motion, were constructed from the railroad company's drawings.

The total weight of the locomotives is 204,050 lbs., of which 165,850 lbs., or 81 per cent., is on drivers. The average proportion of weight on drivers for a consolidation type of locomotive is 89 per cent. The tractive effort is 40,200 lbs., giving a ratio of adhesion of 4.13 and a ratio to the total weight of 5.09. A consolidation locomotive with practically the same total weight and the same factor of adhesion would give a tractive effort of





TWELVE WHEEL (4-8-0 TYPE) FREIGHT LOCOMOTIVE—NORFOLK & WESTERN RAILWAY.



LONGITUDINAL SECTION OF BOILER, 4-8-0 TYPE LOCOMOTIVE—NORFOLK AND WESTERN RAILWAY.

nearly 44,000 lbs., which indicates the big advantage to a railroad company of having a line suitable for the operation of consolidation locomotives. The weight per axle of these 12-wheel engines is nearly 41,500 lbs., and a consolidation of the same total weight would be about 45,400 lbs. In comparing the two types, however, it should not be forgotten that the 12-wheel type permits a longer boiler and hence longer flues, and allows the same amount of heating surface to be obtained with a smaller number of flues and wider bridges. This point will be mentioned later.

The locomotives are arranged with a continuous driving equalization on each side and the second pair of wheels, being the main drivers, are fitted with plain tires. The others are flanged. The main wheels have cast steel centers and the others steeled cast iron. The main frames are of cast steel 4½ in. wide with double front rails of wrought iron.

The cylinders are equipped with 12 in. inside admission piston valves. A very compact design of valve motion has been arranged in which the links are carried on an extension from the frame cross tie back of the first pair of drivers. The links are of the built up type with cast steel side plates and double trunnions. The lifting link is connected to the radius bar ahead of the link, the reverse shaft resting in bearings almost directly above the link. The center line of the valves is 2 in. inside the center line of the cylinders, which makes a rocker arm necessary. Advantage has been taken of the clear space between the frames, due to the design of the valve gear by the installing of three large air drums, arranged as shown in the illustration.

The boiler, which is the most interesting feature of this design, is of the extended wagon top type and carries 200 lbs. pressure. The longitudinal seams are welded for 9 in. at each end and are sextuple riveted with double welt strips. The crown sheet is radial stayed, with one T iron at the front end. A liberal use has been made of flexible stay bolts throughout the breakage zone. The arrangement of these will be seen in the boiler drawing. The back flue sheet is unusually well braced, as is also shown in the illustration. Very liberal spacing has been provided in the water legs around the fire box, the mud ring being 5 in. wide at the sides, the space being increased to 7¾ in. at the crown. The back mud ring is 4 in. wide and the distance between the crown sheet and back head is 8 in. The fire door opening is formed by flanging both sheets outward, the inner sheet being given an easy bend at a large radius. The front mud ring is 5½ in. wide, the water space at this point being practically vertical. The ash pan is of the hopper type with cast iron bottom slides operated by an air cylinder. It is equipped with sprinkler pipes supplied with water from the injector overflow.

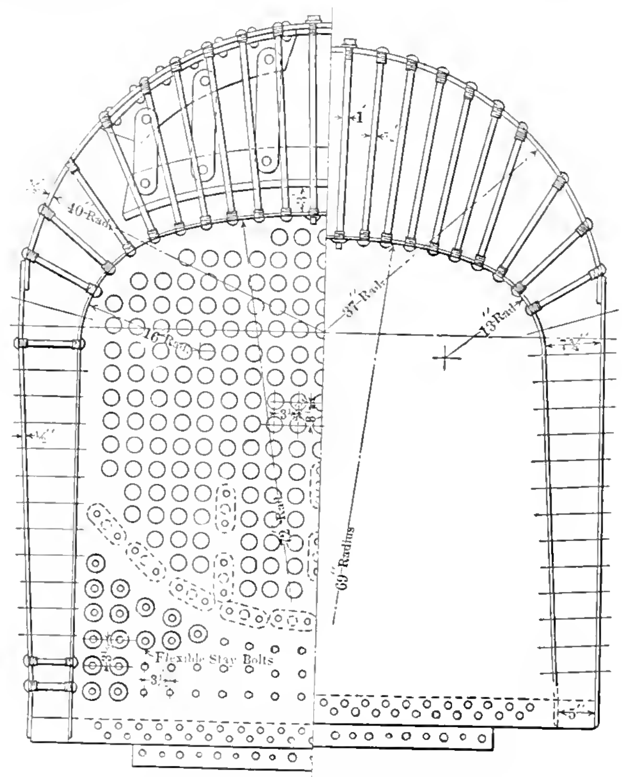
It is interesting to compare this boiler design with that used on a consolidation locomotive built by the same company for the Pennsylvania Railroad, which was illustrated on page 231 of the June, 1906, issue of this Journal. That boiler has practically the same ratios as the one on the Norfolk & Western engine, the flues in the former, however, being but 13 ft. 8½ in. long, while the flues of the Norfolk & Western engine are 18 ft. 4⅞ in. long. The boiler in the former case is 71 in. in diameter at the front end and 70 in. in the latter. The heating surfaces are nearly the same and the difference in the two designs comes altogether in the number, spacing and size of the flues, there being 373 2-in. flues in the Pennsylvania boiler and 242 2¼-in. flues in the Norfolk & Western. The latter engine has but 26 per cent. of the area of the boiler at the front end taken up by flues, while the former has 31 per cent. This illustrates that the 12-wheel design has an advantage in permitting the same amount of heating surface with a much more open arrangement of flues and wider bridges. The flues in this case are arranged in vertical and horizontal rows and have ⅞ in. bridges.

The feed water on these locomotives is discharged from the check valves into a small dome built of ½ in. plates and located on the first ring of the boiler barrel. Water enters the boiler from this dome through sixty-one 1 in. holes drilled through the shell and strikes a deflector plate which delivers it on either side of the dry pipe. The feed dome is practically filled with a series of horizontal baffle plates placed one above the other on which is deposited a large part of the impurities in the feed water. These plates can easily be removed when necessary and replaced with clean ones.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	40,200 lbs.
Weight in working order	204,050 lbs.
Weight on drivers	165,850 lbs.
Weight on leading truck	38,200 lbs.
Weight of engine and tender in working order	320,000 lbs.
Wheel base, driving	15 ft. 6 in.
Wheel base, total	26 ft. 5 in.
Wheel base, engine and tender	53 ft. 7 in.



SECTIONS OF BOILER THROUGH FIREBOX, N. & W. LOCOMOTIVE.

RATIOS.	
Weight on drivers ÷ tractive effort	4.13
Total weight ÷ tractive effort	5.09
Tractive effort × diam. drivers ÷ heating surface	815.00
Total heating surface ÷ grate area	62.00
Firebox heating surface ÷ total heating surface, per cent	5.70
Weight on drivers ÷ total heating surface	60.00
Total weight ÷ total heating surface	74.00
Volume both cylinders, cu. ft	12.00
Total heating surface ÷ vol. cylinders	230.00
Grate area ÷ vol. cylinders	3.71
CYLINDERS.	
Kind	Simple
Diameter and stroke	21 × 30 in.
Kind of valves	12 in. piston
WHEELS.	
Driving, diameter over tires	56 in.
Driving, thickness of tires	3 in.
Driving journals, main, diameter and length	9 × 10½ in.
Driving journals, others, diameter and length	8½ × 10½ in.
Engine truck wheels, diameter	27 in.
Engine truck. journals	5½ × 10 in.
BOILER.	
Style	Wagon Top
Working pressure	200 lbs.
Outside diameter of first ring	70 in.
Firebox, length and width	99⅞ × 64¼ in.
Firebox plates, thickness	crown ⅜, sides ⅜, back ½ tube ⅝ in.
Firebox, water space	front 5½, sides 5, back 4 in.
Tubes, number and outside diameter	242—2¼ in.
Tubes, length	18 ft. 4⅞ in.
Heating surface, tubes	2603 sq, ft.
Heating surface, firebox	157 sq. ft.
Heating surface, total	2760 sq. ft.
Grate area	44.5 sq. ft.
Center of boiler above rail	112 in.
TENDER.	
Wheels, diameter	33 in.
Journals, diameter and length	5¼ × 9 in.
Water capacity	6000 gals.
Coal capacity	10 tons

seated 50 passengers, shown on page 312 of the August, 1907, issue and of the car for the C. R. I. & P. Ry., which seated 52 passengers, illustrated on page 141 of the April issue. Reference to these articles can be made for a description and illustrations of this apparatus.

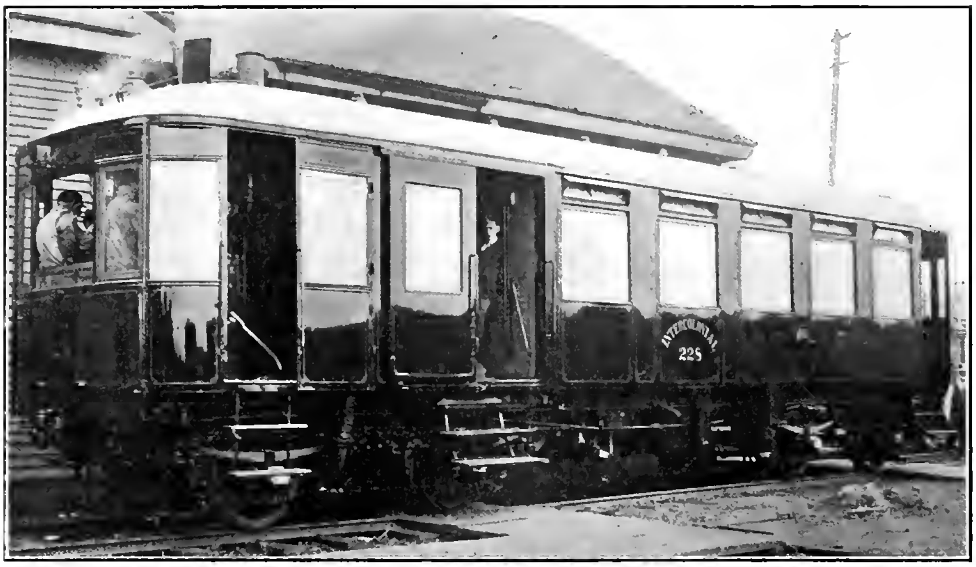
The official tests made on this car before its acceptance by the Railway Company were quite severe. It was operated a distance of 37 miles over the Intercolonial Railway from Moncton to Harcourt, which run was made in 62 minutes, the maximum speed being 43 miles an hour. On a one per cent. grade one mile long, during this run, a speed of 30 miles an hour was attained. The round trip, making a distance of practically seventy-five miles, was made with a coal consumption of 925 lbs., being equivalent to about 12.3 lbs. per mile. The guarantee of the car being 16½ pounds per mile, this test showed it to be 25 per cent. better than its guarantee. Another test was made over a distance of 26 miles with the motor car pulling a trailer weighing 24 tons. The average speed on this run was 31 miles per hour. The Ganz patents and apparatus in this country are controlled by the Railway Auto Car Company of New York.

MALLET COMPOUND LOCOMOTIVES IN ROAD SERVICE.

The Great Northern Railway has 25 Mallet compounds in road service between Spokane and Leavenworth, Washington, a division about 200 miles in length, on which the maximum grade is one per cent. The locomotives are successfully handling 1,450 tons, giving a speed of 10 miles per hour on the maximum grade. Prior to the assignment of the Mallet locomotives in this district consolidation locomotives, with a tractive force of 39,000 lbs., were being used and could handle but a little over 1,100 tons. Hence the Mallets are handling 30 per cent. more tonnage and are burning practically the same amount of fuel.

These locomotives were illustrated on page 213 of the June issue of this journal and weigh 302,650 lbs. total, of which 263,350 lbs. is on drivers. They are of the 2-6-6-2 type and have a tractive effort of 57,940 lbs. The drivers are 55 in. in diameter and the steam pressure is 210 lbs.

Prizes for Track Supervisors.—The Pennsylvania Railroad distributed $5,400 in prizes during the past month to the track supervisors whose tracks had been kept in the safest and most perfect condition. There was a prize of $1,200 for the line best maintained during the year and a prize of $1,000 for the division showing the greatest improvement during the year. There were also four prizes of $800 each for other divisions where the maintenance or improvement during the year has been especially good



GANZ STEAM MOTOR CAR—INTERCOLONIAL RAILWAY OF CANADA.

GANZ STEAM MOTOR CAR.

Intercolonial Railway.

On page 391 of the October issue of this journal is illustrated and described a steam motor car, three of which have recently been designed and built in the shops of the Intercolonial Railway of Canada. The same company has also received a 120 h.p. steam motor car of the Ganz type, the appearance of which is shown in the illustration.

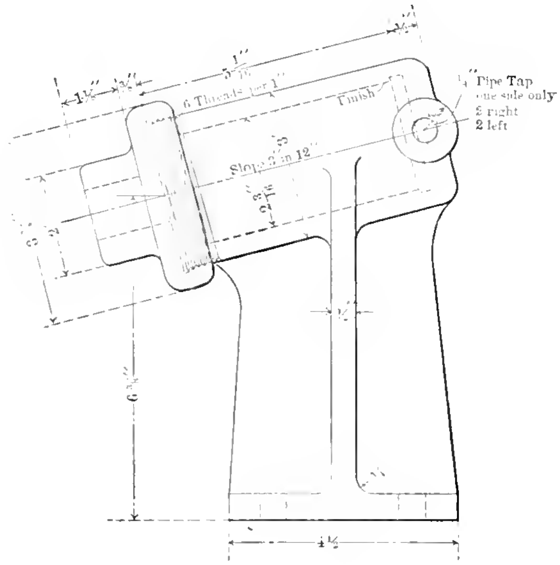
This car was imported direct from the European works of the company and has a seating capacity of 40 passengers. It is divided into four compartments, the one at the forward end, 7 ft. long, containing the steam generator, control levers and all accessory apparatus. Back of this is a baggage compartment, 7 ft. long, which is followed by a smoking compartment seating eight passengers.

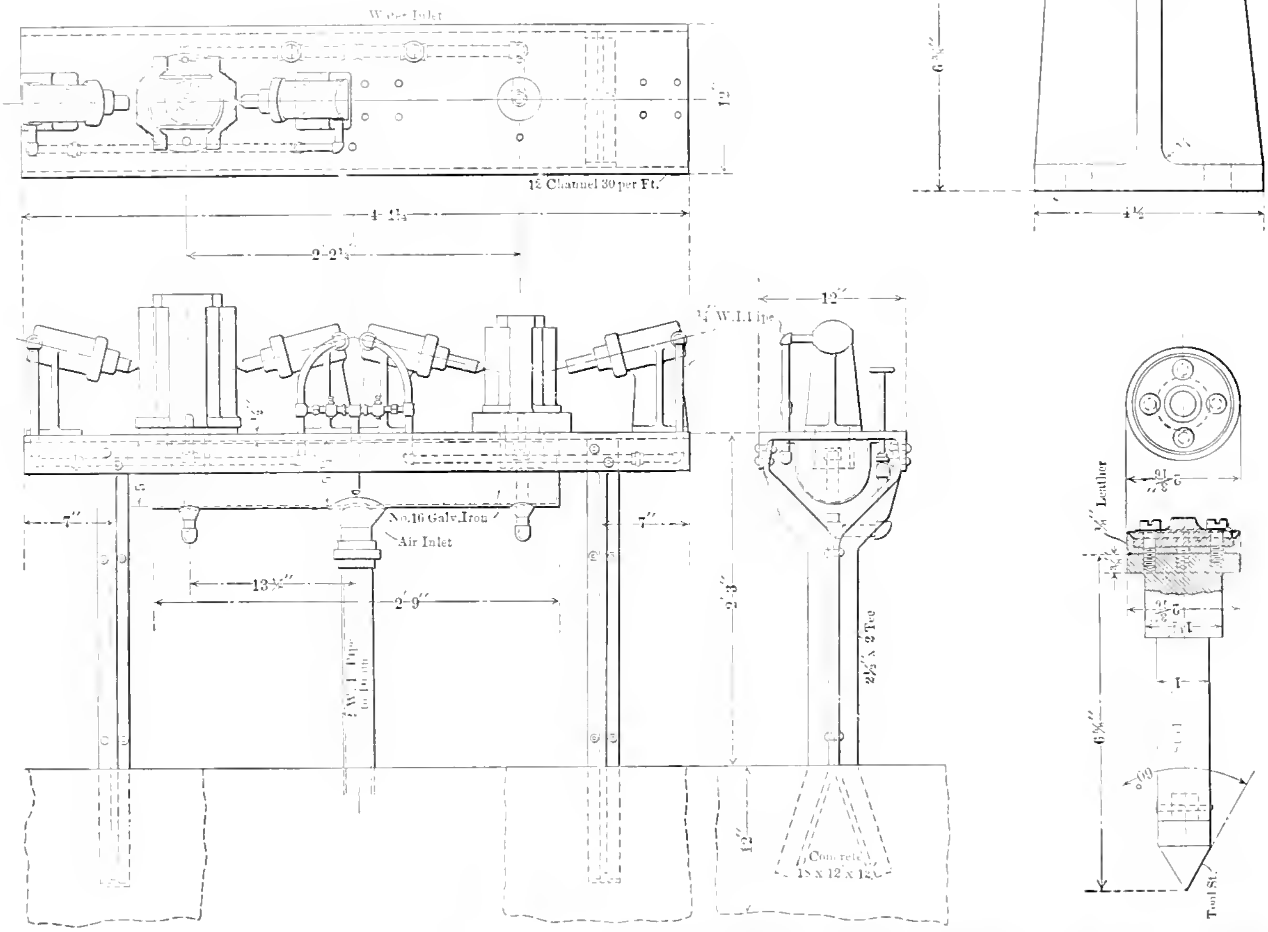
The framing and exterior finish is of steel, the interior finishings being hard wood. The seats are upholstered in leather. The car is heated by steam and lighted by acetylene gas.

The steam generating apparatus and the steam motor are of the standard Ganz type, which has been illustrated in this journal in connection with a car built for the Erie Railroad, which

LINING CAR BRASSES.

The illustrations show a device, in use at the Collinwood shops of the Lake Shore & Michigan Southern Railway, for lining car brasses. The apparatus consists of two pairs of air cylinders mounted on a 12-inch channel, as shown. The cylinders are bored to 2 3/16 in. The piston rod is inclined downward and pointed at the end so that when air is admitted to the cylinders the brasses are held firmly against the mandrel. A coil spring is fitted in the cylinder so that when the pressure is released the piston will be forced back and the brass can easily be removed.

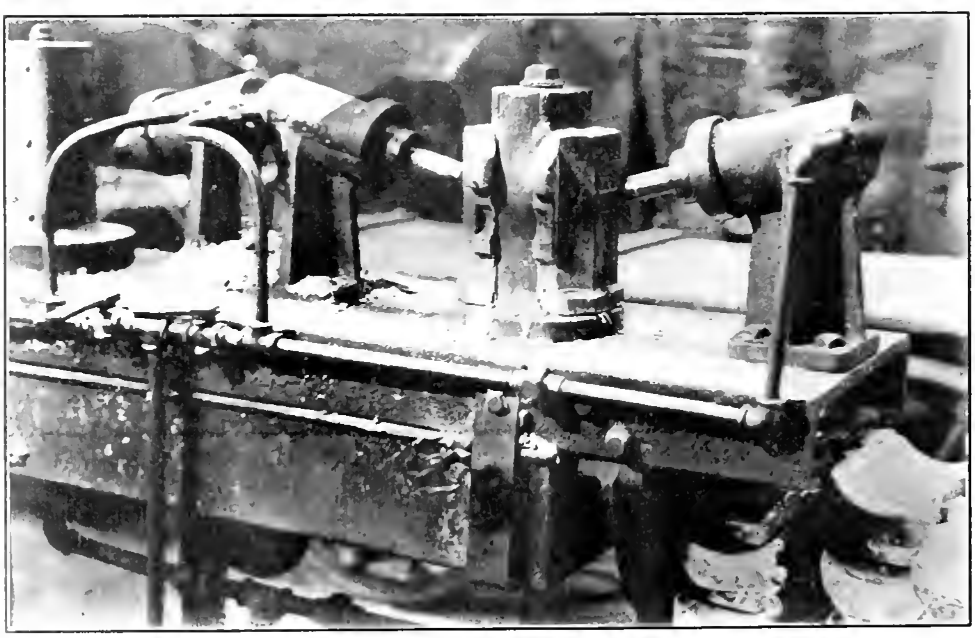




DETAILS OF DEVICE FOR LINING CAR BRASS.

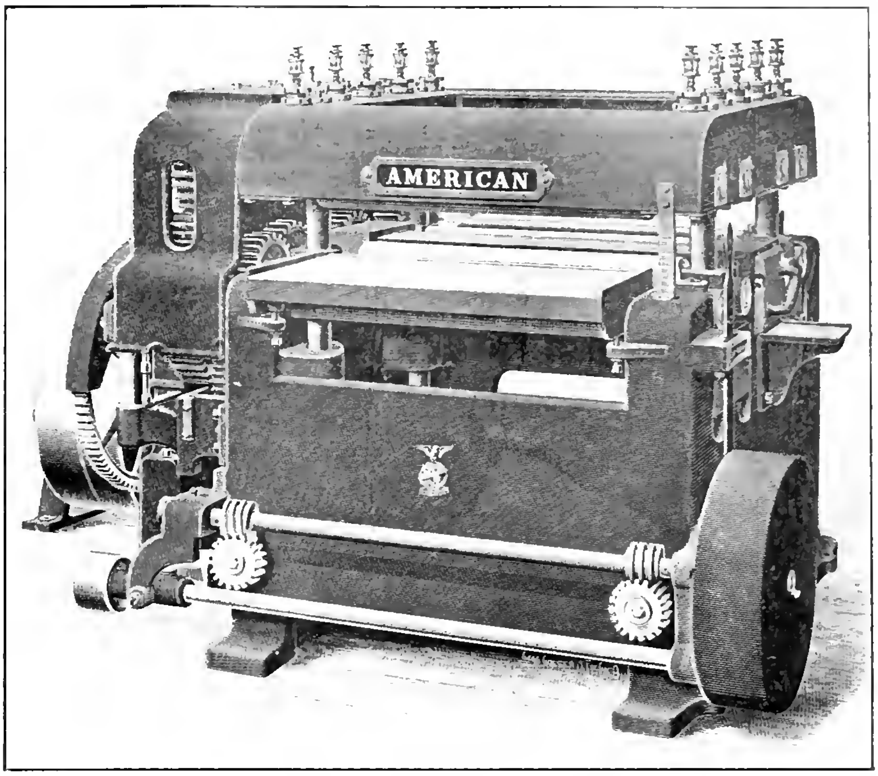
The mandrel is cored hollow and streams of water are played on the inside, by means of a pipe cap with four 1/8-in. holes in it, which is placed on the end of the supply pipe, thus cooling the lining metal as it is poured. Guide strips are cast on each side of the mandrel to hold the brasses the proper distance from it. The brasses are tinned before lining.

New Design of Pedestal Binder.—Our attention has been called to the fact that the pedestal binder published on page 301 of the September issue, under the above caption, is not altogether new, since this type of binder was patented by Mr. John Player, now consulting engineer of the American Locomotive Company, on December 9, 1890, and has been in use in slightly modified forms on the New York, Chicago & St. Louis Rail-



LINING CAR BRASSES—COLLINWOOD SHOPS.

road, the Lake Shore & Michigan Southern Railway, and some other roads since that date. Several modifications of this design have been made to suit special conditions. One of these is adapted for the rear pedestal of trailing truck engines where the frame is of the slab form and set down behind the pedestal jaw so that it is not practicable to use a foot. In that case the binder is hinged around a 2½ in. pin passing through the frame at the rear and has a set screw arrangement, similar to the one illustrated, in front.



AMERICAN 30-INCH SCRAPING MACHINE.

30-INCH SCRAPING MACHINE.

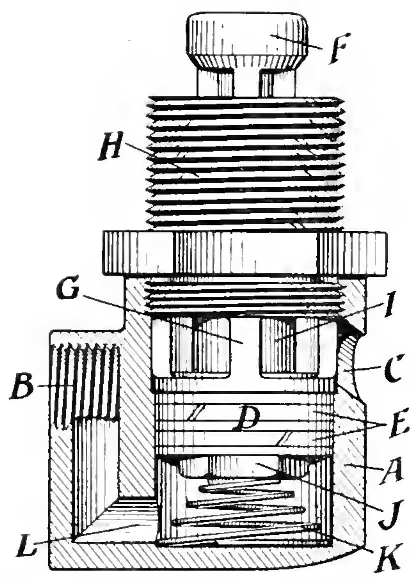
The illustration shows a 30-in. scraping machine, as made by the American Wood Working Machinery Company, Rochester, N. Y. These machines perform about the same function as sanders and are better adapted for certain classes of work. A thin knife held firmly in a stock, with its edge projecting slightly above the face of the stock, forms the principal feature of the machine. The work is fed over the knife by powerfully driven smooth rolls operating at a high speed. A thin shaving is removed, leaving a smooth surface ready for the finishing room.

As may be seen, the frame is of heavy and substantial construction. There are eight feed rolls all driven by heavy gears. The stock which holds the knife is in two parts with a slot for the knife in the center. The top face is made of chilled iron accurately ground to a true surface and having in the center a flat face of 4½ in. against which the knife is placed. On the other side of the knife is an accurately finished plate, which is drawn up against the knife by set screws, holding it rigidly. Two of these stocks are furnished with each machine, and when one knife becomes dull it can be withdrawn and the other one instantly inserted without stopping the machine. The pressure roll over the knife is controlled by strong springs, which hold the work firmly to the knife at all points. The knife may be used for cutting on both edges and may be ground until it becomes too narrow to be firmly held in the stock. The machine illustrated has a capacity for pieces 30 in. wide and 4 in. thick. These machines are also made in three other sizes, 12, 20 and 42 in.

LARGEST STEAMSHIP IN THE WORLD.—The steamship Lusitania of the Cunard Line, which has broken all records for speed of transatlantic liners, is driven by four Parsons turbines, each driving a separate screw. The two inner ones are high pressure turbines and the two outer ones are low pressure. There are also two smaller turbines for the astern movement. The propellers were designed to make about 140 revolutions per minute, the turbines making the same. The rotor of the high pressure turbines is 96 in. and the low pressure 140 in. in diameter. The blades range from 2¼ to 22 in. in length. The vessel contains 25 Scotch boilers, of which 23 are double ended, with eight furnaces, and two are single ended, giving a total of 192 furnaces. The steam pressure is 195 lbs. The total heating surfaces of all the boilers is 158,350 sq. ft. and the total grate area is 4,048 sq. ft. The turbines are designed to give a total horse-power of 68,000. The vessel measures 785 ft. over all and is 88 ft. broad at the widest point, the mean draught being 33 ft. 6 in. and the displacement 38,000 tons. During its trials this vessel made an average speed of 25.4 knots on a 48 hour run.

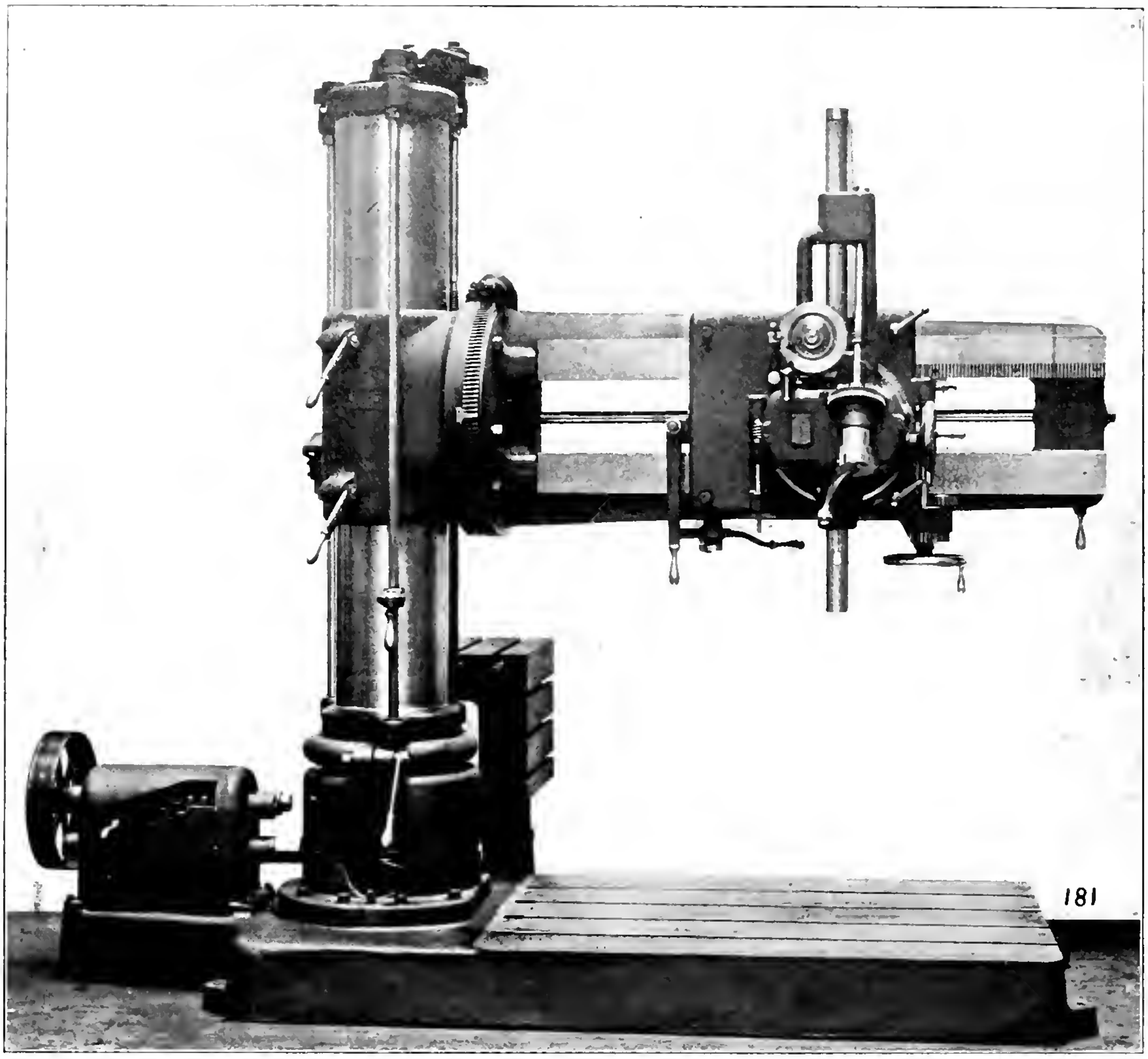
AUTOMATIC CYLINDER COCK.

A sectional view of the Dolph automatic cylinder cock is shown in the accompanying illustration. When steam is being used the pressure on the upper surface of the winged valve F forces it down on its seat. When steam is shut off the spiral spring K forces the piston D upward, carrying with it the valve F and permitting the cylinder condensation to escape through the opening C in the valve body. In case it should be necessary to open the cylinder cock while steam is being used, compressed air is admitted at B, passes down through the passage L and underneath the piston D, forcing it upward against the pressure of the steam on the valve F and opening the cock. Compressed air is sup-



plied from the main reservoir through an operating valve in the cab.

In addition to the advantages gained due to the automatic action, the awkward and ofttimes unsatisfactory cylinder cock rigging is done away with; there is considerably more clearance between the road bed and the bottom of the cock, thus reducing the liability of its being torn away. These valves are being used on several railroads with satisfactory results and are made by the Dolph Valve Company with offices at Buffalo, N. Y., and Erie, Pa.



NEW BICKFORD UNIVERSAL RADIAL DRILL.

NEW UNIVERSAL RADIAL DRILL.

The Bickford Drill & Tool Company, Cincinnati, O., is placing a new line of universal radial drills on the market, similar to the one shown in the illustration. It is claimed that the design of the arm offers much greater resistance to the combined stresses of twisting and bending than in their former designs. Also that this, combined with the exceptional facilities which the open form of arm offers for the introduction of a driving mechanism commensurate with the strength, power and durability obtainable in the other parts, marks an important advance in universal radial drill construction—obtaining a degree of efficiency equal to that of a plain machine.

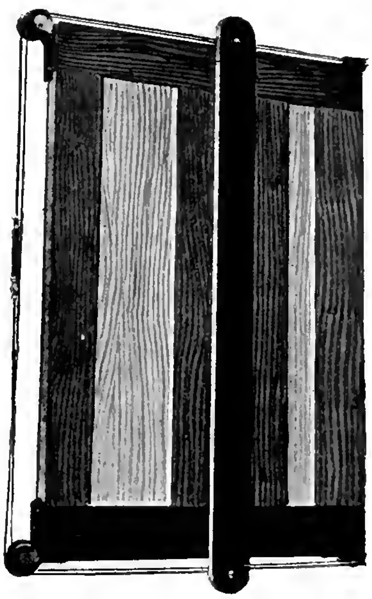
The sleeve is mounted on a stationary stump which extends up to and has a bearing at the top of the machine. This is equivalent to a double column, and affords that stiffness which is so essential to true work. The arm may be rotated through a complete circle on its girdle, and the head through a complete circle on its saddle, which permits drilling at all angles radiating from the center of a sphere. The back gears are located back of the saddle and may be engaged or disengaged from the front of the machine while it is running. They furnish three changes of speed, each of which exerts at the spindle more than two and one-half times the pulling power of the next faster one. The spindle has fifteen changes of speed with the cone drive and twenty-four with the gear drive, and is provided with both hand and power feed, quick advance and return, safety stop, automatic trip, dial depth gauge and hand lever reverse. An engraved plate attached to the speed box shows how to obtain the proper speeds for different diameters of drills.

The depth gauge answers a double purpose: it enables the operator to read all depths from zero, thus doing away with the usual delays concomitant to scaling and calipering; it supplies a convenient means for setting the automatic trip, the graduations showing exactly where each dog should be located in order to disengage the feed at the desired points. The automatic trip operates at as many different points as there are depths to be drilled at one setting of the work; in addition, it leaves the spindle free, after any intermediate tripping, to be advanced, or raised and advanced, or traversed its full length, without disturbing the setting of the dogs; it also throws out the feed when the spindle reaches its limit of movement. The feeding mechanism furnishes eight rates of feed, ranging in geometrical progression from .007 in. to .064 in. per revolution of spindle; each of these is instantly available, eliminating all loss of time incident to shifting a belt or to operating under a feed of unnecessary fineness. An engraved plate attached to the head shows the operator how to obtain each of the feeds.

The tapping mechanism is located on the head, and permits the backing out of taps at any speed, regardless of that used in driving them in. It is fitted with a friction clutch operated by a lever, the handle of which extends around under the arm within convenient reach of the operator. The driving mechanism is incased in a box made fast to the base of the machine, and consists essentially of a pulley, a cone of seven gears, a ratchet, ratchet gear and operating lever, the mere shifting of which from one notch to another furnishes any one of eight speeds. This box, taken in connection with the back gears on the head, gives the operator a choice of twenty-four carefully selected speeds, each of which is instantly available. The machine is furnished as either half or full universal, each of these styles being made in three sizes—4, 5 and 6 feet.

DRAWING BOARD PARALLEL MOTION ATTACHMENTS.

The difficulty of doing accurate work on a large drawing board, with an ordinary tee square, is too well recognized to require comment. There are a number of devices on the market for using a straight-edge, in place of a tee square, with attachments for keeping it in a parallel position. The important feature of the parallel motion attachments, which are clearly shown on the accompanying engraving, is the use of ball bearings in connection with the wheels, or pulleys, at the corners of the board. The wheels do not require any readjustment, after once



PARALLEL MOTION ATTACHMENTS FOR DRAWING BOARD.

being attached, require no lubrication and reduce the friction, and therefore the liability of distorting the motion, to a minimum.

The attachments may be easily applied and the board is not at all disfigured, if it is desired to remove them. They are of steel, nickel plated, and neat and attractive in appearance. The cost is so low, and the possibility of greater accuracy and rapidity of doing work on the smaller, as well as large boards, is so great that no drawing room should be without them. They are made by the Knipe Manufacturing Company, manufacturers of the Knipe multiple ball bearings, with offices in the Drexel Building, Philadelphia, and works at Worcester, Mass.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION

The sixth annual convention of the National Machine Tool Builders' Association was held at the Hotel Imperial, in New York, October 15 and 16. The reports indicate that the association is in splendid condition. The membership has been increased from 76 to 81 since the spring meeting. Among other things a committee report was presented as to the value of exposition displays and a standard form of diploma was adopted for graduate apprentices; also a form of contract designated as "The National Machine Tool Builders' Apprenticeship Contract."

The spring meeting will be held at Atlantic City. The following officers were elected: President, Fred. L. Eberhardt, Gould & Eberhardt, Newark, N. J.; first vice-president, C. A. Johnson, Gisholt Machine Company, Madison, Wis.; second vice-president, E. P. Bullard, Jr., Bullard Machine Tool Company, Bridgeport, Conn.; secretary, P. E. Montanus, Springfield Machine Tool Company, Springfield, Ohio; treasurer, W. P. Davis, W. P. Davis Machine Company, Rochester, N. Y.

Street Car Accidents in New York City.—A table which has recently been issued by the Public Service Commission of New York City shows that the total number of accidents from August 4 to 31 on the transit lines within New York City was 5,500. There were 159 of what are classed as serious accidents in which 42 people were killed.

PERSONALS

Mr. W. J. Buchanan, master car builder of the Bessemer & Lake Erie R. R., with office at Greenville, Pa., has resigned.

Mr. W. G. Wallace, superintendent of motive power of the Ann Arbor Railroad and the Detroit, Toledo & Ironton, has resigned.

Mr. F. M. Titus has been appointed general inspector of the American Locomotive Company, with headquarters at Schenectady, N. Y.

Mr. A. T. Livingston, acting storekeeper, has been appointed storekeeper of the New York Central & Hudson River R. R. at Albany, N. Y.

Mr. E. M. Peden has been appointed superintendent of motive power and rolling stock of the Santa Fe Central Ry., with office at Estancia, N. M.

Mr. S. H. Spangler has been appointed master mechanic of the St. Louis, Watkins & Gulf Ry., with office at Lake Charles, La., vice Mr. J. C. Ramsey.

Mr. James Stockton, general foreman of the New Orleans & Northeastern R. R., has resigned to become master mechanic of the New Orleans Terminal Co.

Mr. T. Rumney, mechanical superintendent of the Erie R. R., with office at Meadville, Pa., has been promoted to general mechanical superintendent, with office in New York.

Mr. F. W. Dickinson, general foreman of the car department of the Bessemer & Lake Erie R. R., at Greenville, has been promoted to master car builder, succeeding Mr. Buchanan.

Mr. J. H. Cragin has been appointed general storekeeper of the San Pedro, Los Angeles & Salt Lake R. R., with offices at Los Angeles, Cal., to succeed Mr. L. B. Stiles, resigned.

Mr. Joseph W. Walker has been appointed chief air and motive power inspector of the Pennsylvania Railroad, Western Pennsylvania grand division, with office at Pittsburg, Pa.

Mr. Edward F. Fay, general foreman of shops of the Union Pacific R. R. at Omaha, Neb., has been appointed master mechanic at Denver, Colo. He is succeeded by Mr. George Brown.

Mr. William Schlafge, assistant mechanical superintendent of the Erie R. R. at Meadville, has been made mechanical superintendent of the Erie grand division, with office at Jersey City, N. J.

Mr. J. H. Nash, division master mechanic of the Illinois Central R. R. at East St. Louis, Ill., has been appointed division master mechanic at Paducah, Ky., vice Mr. R. E. Fulmer, resigned.

Mr. A. G. Trumbull, assistant mechanical superintendent of the Erie R. R. at Meadville, has been made mechanical superintendent of the Ohio division and the Chicago & Erie, with office at Cleveland, Ohio.

Mr. A. W. Wheatley, general inspector of the American Locomotive Company at Schenectady, has been appointed a manager of that company, with headquarters at the Ottawa Bank Building, Montreal, Canada.

Mr. E. J. Harris, general foreman of shops of the Chicago, Rock Island & Pacific Ry. at Valley Junction, Ia., has been appointed master mechanic at that point, succeeding Mr. D. W. Cunningham, resigned.

Mr. A. Buchanan, Jr., superintendent of motive power of the Central Vermont Ry., has resigned to accept a position on the Public Service Commission, 2nd district, New York, with headquarters at Albany, N. Y.

Mr. R. C. Evans has been appointed superintendent of the motive power and car departments of the Western Maryland R. R., with headquarters at Union Bridge, Md., in place of Mr. William Miller, resigned, account of ill health.

Mr. J. E. Cameron, superintendent of motive power of the Atlanta, Birmingham & Atlantic R. R. at Fitzgerald, Ga., has resigned and will devote his entire attention to construction work as superintendent of construction at Talladega, Ala.

Mr. James Holden, locomotive, carriage, and wagon superintendent of the Great Eastern Railway, England, will retire at the end of the year. Mr. Stephen Dewar Holden, assistant locomotive superintendent, has been appointed to succeed him.

Mr. Martin P. Ford, a charter member of the Master Car Builders' Association and designer of a sleeping car which was in service for several years before Pullman's invention was brought out, died at Columbus, O., on Sept. 16. Age, 83 years.

Mr. R. Tawse, master mechanic of the Ann Arbor Railroad, has been appointed superintendent of motive power of the Ann Arbor and the Detroit, Toledo & Ironton, with headquarters at Jacksonville, Ohio. Mr. Tawse succeeds Mr. W. G. Wallace, resigned.

Mr. Robert McKibben, master carpenter of the Monongahela division of the Pennsylvania Railroad at Pittsburg, Pa., has been promoted to master carpenter of the Middle division, with headquarters at Altoona, Pa. He succeeds Mr. A. H. Kline, promoted.

Mr. H. Montgomery has been appointed superintendent of motive power and equipment of the Bangor & Aroostook R. R., with office at Milo Junction, Me., and the position of assistant superintendent of motive power and equipment is abolished. Mr. Montgomery succeeds Mr. Orlando Stewart, resigned.

Mr. Alfred Lovell has tendered his resignation as superintendent of motive power of the Atchison, Topeka & Santa Fe Ry. to engage in private business. He has been in the service of the Santa Fe since September, 1902, when he became assistant superintendent of motive power, and in February, 1905, was promoted to the office of superintendent of motive power. Mr. Lovell is a graduate of the Worcester Polytechnic Institute class of '73. After several years' experience on eastern roads, he, in 1890, entered the service of the Northern Pacific Ry. as superintendent of construction of new shops at Tacoma, and from 1894 to 1902, was successively acting mechanical engineer, engineer of tests, assistant superintendent of motive power and superintendent of motive power of that road.

BOOKS

Switches and Turnouts. By Howard Chapin Ives. Bound in paper; 6 x 9 in.; 40 pages. Published by the Worcester Polytechnic Institute. Mr. J. D. Williams, sales agent, Worcester, Mass. Price, 50c.

This book is a reprint of three articles which appeared in the Journal of the Worcester Polytechnic Institute. It gives descriptions of the different forms of switches and their effect upon the lead and gives the theory, including the mathematics, used in the design of switches and turnouts. The arrangement is in the form of problems followed by their solution.

Modern British Locomotives. By A. T. Taylor. Bound in cloth; 110 pages; 5 x 7½ in. Published by Spon & Chamberlain, 123 Liberty Street, N. Y. Price $1.80.

This book includes 100 diagrams of British locomotives, giving the principal dimensions, weights, etc. The diagrams are grouped according to type and represent the latest practice on all of the leading railways of Great Britain.

Railway Corporations as Public Servants. By Henry S. Haines. Bound in cloth; 5½ x 8 in.; 226 pages. Published by the Macmillan Co., 66 5th Ave., New York. Price $1.50.

This book contains the substance of the course of lectures delivered before the Boston University School of Law and is to some extent supplementary to a previous work of the same author on "Restrictive Railway Legislation." It describes the development of such legislation since the passage of the act to regulate interstate commerce. The author is a member of the A. S. C. E.; A. S. M. E.; was formerly vice-president and general manager of the Plant System; is an ex-president of the American Railway Association and a commissioner of the Southern States Freight Association.

Poor's Manual of Railroads 1907. 40th Annual number. Published by Poor's Railroad Manual Co., 68 William St., New York. Price $10.00.

This is in all respects the most complete volume of the entire series, embracing 2,000 pages of condensed information concerning the railroad, street railway and industrial corporations of the U. S. The introduction gives the statistics of the American railway system as a whole for the year ending 1906 and is highly interesting and instructive. It shows, for instance, that the average rate per passenger mile for the year ending 1906 was 2.011c. as against 2.028c. in 1905. The average freight revenue per ton mile was .776c. as against .784c. The average interest rate on bonds was 3.99 per cent. and the average dividend rate on railroad stock was 3.63 per cent. The information contained in the introduction and in the Manual itself is of special interest at present owing to the agitation of railway matters in the press and the regulation of railway affairs by the different legislatures.

The Blacksmith's Guide. By J. F. Sallows. Published by The Technical Press, Brattleboro, Vt. Pocket size, 4½ x 7 in.; 160 pages; 165 illustrations; cloth binding, $1.50; leather, $2.00.

This book was written by a practical blacksmith, who has had a very wide experience, and who is at present foreman blacksmith of the Reo Motor Car Company, Lansing, Mich. The book is well printed on heavy paper and the illustrations are especially good. The sub-divisions of the different chapters are indicated by side heads in bold-face type. After some general suggestions, the method of making various tools for the blacksmith and machine shop is clearly and briefly described. Directions for making different kinds of welds are then given. The second chapter considers the making of hand and machine cutting tools. Following this are chapters on hardening and tempering high speed steel, case hardening and coloring, brasing, and general blacksmithing. There are three colored illustrations, one showing a heat chart, another a temper chart and the third the effects obtained by case-hardening and coloring a wrench. A folder shows the working drawings for a coal burning case-hardening furnace.

The Strength of Wood as Influenced by Moisture:—Published by the Forestry Service, U. S. Department of Agriculture, Washington, D. C. Sent free upon application.

The effect of water in softening organic tissue, as in wetting a piece of paper or a sponge, is well known, as is also the stiffening effect of drying. The same law applies to wood. By using different methods of seasoning, two pieces of the same stick may be given very different degrees of strength. Wood in its green state contains moisture in the pores of the cells and also

in the substance of the cell walls. As seasoning begins the moisture in the pores is first evaporated. This lessens the weight of the wood but does not affect its strength and it is not until the moisture in the substance of the cell walls is drawn upon that the strength of the wood begins to increase. From this point to that of absolute dryness the gain in the strength of wood is somewhat remarkable. In the case of spruce the strength is multiplied four times; and this wood, in small sizes, thoroughly dried in the oven, is as strong, weight for weight, as steel. This publication includes tables and complete information showing the strength of representative woods for all degrees of moisture, from the green state to absolute dryness, as well as the effects of re-soaking.

Laying Out for Boiler Makers. Bound in cloth; 10 x 13 in.; 189 pages. Published by the Boiler Maker, 17 Battery Place, New York. Price $4.00.

This book has been compiled for the purpose of giving a practical boiler maker the necessary information to enable him to lay out in detail the different types of boilers, tanks, stacks and irregular shape metal work. The practical application of many of the principles of geometry, mechanics, etc., involved in this subject have been explained in a practical way in connection with different jobs of laying out which form a part of the every day work in every boiler shop. The subject is handled entirely from a practical standpoint and contains only such theory and mathematics as are absolutely necessary for the practical work. The first two chapters explain the methods of laying out by orthographic projection and triangulation, since these are the two principal methods used in solving any problems in laying out. A few simple problems are given in each case, from which the application of the methods to more complicated problems may be learned. The chapters which take up the detailed layouts of different types of boilers also give the rules for determining the size, shape and strength of the different parts. The work covers its field very completely and is profusely illustrated with half-tones and clear-cut line drawings. The matter contained in the book first appeared in the pages of the *Boiler Maker* and have been reprinted from that source. This work will be found to be of great practical value to all boiler makers and boiler maker foremen.

Proceedings of the Railway Storekeepers' Association. Fourth annual meeting, held at Chicago, May 20-22, 1907. Cloth, 213 pages (not including illustrations and folders), 6 x 9 in. Secretary, Mr. J. P. Murphy, Collinwood, O.

Several of the papers are of special value to the mechanical department officials. Messrs. J. H. Waterman, of the Burlington, N. M. Rice, of the Santa Fe, and H. A. Anderson, of the Pennsylvania, each read papers on "Should the Jurisdiction of the Storekeeper, or Supply Agent, Extend to the Time the Material Is Actually Used?" This question precipitated a lively and extended discussion. The topic, "To What Extent Is the Store Department Beneficial to the Motive Power Department?" was considered in papers by Messrs. H. W. Jacobs, of the Santa Fe, C. B. Foster, of the T. St. L. & W., and L. R. Johnson, of the Canadian Pacific.

Other important papers were: "A Unit of Comparison," by Mr. Geo. G. Yeomans: "Reports and Statistics of Value to the Store Department"; "Importance of Proper Loading of Material at General Storehouses to Conserve Cars and Expedite Delivery"; "The Modern Supply Car as a Factor of Economy in the Distribution of Material"; "Benefits Derived from the Classification of Material"; "The Handling of the Storekeeper's Accounts"; "Best Record for Material Received, and Passing Invoices"; Is the Store Department Deficient Without a Traveling Storekeeper?" and "The Most Practical Railway Store Department Organization." Individual papers were presented by Mr. M. B. Wild, statistician of the Baltimore & Ohio; by Mr. H. C. Stevens on "Information of Importance which Should at All Times be in the Hands of the General Storekeeper," and by Mr. H. E. Ray on "Reorganization of the Store Department on the Santa Fe."

The association now has a membership of 253, an increase of 40 per cent. in one year. This volume, like its predecessors, is well printed and carefully arranged. A feature which adds considerably to its value and appearance is the half-tone illustrations showing the arrangement of different "up-to-date" store houses, or of apparatus used in connection with them. There are 26 of these illustrations.

Development of the Locomotive Engine. By Angus Sinclair. Bound in cloth; 6 x 9; 661 pages; illustrated. Published by the Angus Sinclair Company, New York. Price $5.00.

The careful student of any subject finds the history of his specialty to be a most valuable part of his equipment and the study of the development of any art, practically of the mechanic arts is always interesting even to those who are not intimately connected with it. A work of this kind, to be successful, should be written by a man of broad experience, wide acquaintance and long connection with his subject, who is able to see the various stages of the development in their proper prospective and to eliminate the large amount of unimportant material.

The book we are considering seems to fulfil these conditions in every way. The author is one of the best known students and writers on locomotive affairs in the country, who numbers among his friends the prominent figures responsible for the tremendous progress of the locomotive during later years, in which progress he himself has greatly assisted. The book contains many photographs and brief sketches of the personal record of these men, as well as of those great minds of the earlier periods. It fulfils its title very completely by showing each step in the development of the locomotive as a whole and of its more important parts. The chapters showing the development in America are arranged in sections covering the progress on each road, beginning with a general chapter illustrating a few of the earliest imported and American engines, followed by chapters on the B. & O. Railroad, Camden & Amboy R. R., Philadelphia & Columbia R. R., Baldwin Locomotive Works, Sellers and other Philadelphia pioneers in locomotive building; New York Central R. R., New England Railways, etc. The development on western railroads and chapters on locomotive boilers, valve gears, freaks and curiosities, train brakes, accessories, present locomotive works, and a chapter entitled "The Locomotive Today" complete the work. We would recommend this book to all students of locomotive history.

CATALOGS

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS JOURNAL.

Cold Metal Saw.—Catalog No. 5 from the Lea Equipment Company, 136 Liberty street, New York, describes in detail the Lea-Simplex cold metal saw. These are made in several sizes and may be arranged for either belt or motor drive.

"Spike Strut."—The Maryland Railway Supply Company, Continental Building, Baltimore, Md., is issuing a small catalog illustrating and describing the "Spike Strut," which is designed to reinforce track spikes wherever greater resistance is required.

Oil House Equipment. Bulletin No. 4002, recently issued by S. F. Bowser & Co., Fort Wayne, Ind., is devoted to the Bowser system of oil storage, as specially adapted to the needs of railway store houses, terminals, signal towers, etc. It describes in detail the construction of the different styles of pumps, tanks and accessories manufactured by this company and is profusely illustrated with views of installations recently completed.

Ball and Roller Bearings.—The Standard Roller Bearing Co., 48th street and Girard avenue, Philadelphia, is issuing catalog No. 12, containing illustrations, descriptions and details of sizes and prices of the large variety of ball and roller bearings manufactured by it. These bearings are designed for practically all purposes where friction is to be overcome and are shown in a surprisingly large number of shapes and sizes, for all purposes from a bicycle to a street car.

Electrical Apparatus.—The Fort Wayne Electric Works, Fort Wayne, Ind., is issuing Bulletin No. 1100 on the subject of type L. small, direct-current generators, which are illustrated and described both as to their construction and application to machine tools and similar apparatus. Bulletin No. 1098 is on the subject of type M. P. L. belted generators, which are described in detail. These generators are made in capacities from one to four hundred k. w. The same company is issuing instruction book No. 3028 on the subject of single phase integrating induction wattmeters.

Tate Flexible Staybolt.—The Flannery Bolt Company, 308 Frick Building, Pittsburg, is issuing a leaflet illustrating a locomotive boiler fitted with a complete set of flexible stay bolts and containing a complimentary letter recently received from a prominent mechanical superintendent.

Metallic Packing.—H. W. Johns-Manville Co., 100 William street, New York, is issuing a catalog descriptive of the Morris metallic packing, of which it has undertaken the exclusive sale. This packing has been in use for several years and has proved itself to be remarkably successful under the most severe conditions. The catalog illustrates the packing as used on both rotary and reciprocating valve stems.

Pond Rigid Turret Lathe.—A handsomely illustrated catalog from the Niles-Bement-Pond Company, 111 Broadway, New York. These machines are made in two sizes, 21 and 28 inch, and are designed for producing economically work ordinarily done on engine lathes and heavy bar work. The first part of the catalog describes the machines in detail, with several illustrations. The tool equipment is then considered, after which illustrations are given showing how various classes of work are handled. This is followed by drawings of different types of work which may be done to advantage on these lathes.

Thermit Welding Instructions.—The Goldschmidt Thermit Co., 90 West street, New York City, is issuing several pamphlets giving complete and specific directions covering the various applications of thermit, special attention being given to the repair of locomotive parts. The moulds for use in welding frames and other parts are illustrated and the best method of application and the procedure preceding the ignition of the thermit, as well as following it, is clearly explained. The chemical and physical changes following the ignition are briefly covered and every step in the operation of thermit welding is carefully explained.

Modern Welded Pipe.—The National Tube Company, Frick Building, Pittsburg, Pa., is issuing a very attractive booklet on the subject of modern welded pipe, which describes in detail the manufacture from the ore to the finished product. The subject is treated in a popular manner and is intended to familiarize all users of pipe with the properties of the materials involved and their treatment in the course of manufacture. It is profusely illustrated with excellent half-tone illustrations, giving views of the different processes, from the mining of the ore to the testing of the pipe. This book will be found interesting and useful to all users of piping of any kind.

Hydraulic Pumps.—The Watson-Stillman Co., 26 Cortlandt street, New York, is issuing sectional catalog No. 71, which, like other catalogs from the same company recently mentioned in this column, is an assortment of sheets selected from its large amount of printed matter, which in this case relate specially to hydraulic pumps and accessories. It includes illustrations and descriptions, together with prices, of both hand and power driven pumps in all conceivable shapes and sizes, many of which have been developed for special purposes. It also includes many illustrations with accompanying descriptive matter of hydraulic accessories, such as accumulators, accumulator attachments, gauges, packing rings, etc.

The Republic Friction Draft Gear.—The Republic Railway Appliance Company, Chicago, is issuing an attractive catalog descriptive of its type of friction draft gear. The gear is shown by half-tone illustrations, line drawings and phantom views as applied to cars with both steel and wooden sills, for freight and passenger service. This gear is composed of the ordinary M. C. B. spring and buffer plate, with the friction parts so arranged as to act as an auxiliary for increasing the capacity of the spring gear. It occupies the same relation to the coupler and attachments as does the ordinary spring draft gear and the entire apparatus is mounted in the yoke and placed within the pocket as in the ordinary construction.

Hydraulic Engines.—The Rife Hydraulic Engine Mfg. Co., 111 Broadway, is issuing a catalog descriptive of the Rife hydraulic engine, which is constructed upon an entirely new application of hydraulic principles. These engines will work under a fall of two or more feet, will force water to a height of 30 feet for each foot of fall and are entirely automatic, needing practically no attention except the renewing of valves every few years. The principle of the engine, together with a complete description of its construction and operation, thoroughly illustrated with half tone and line drawings, is given in the catalog. These engines are made in capacities up to one million gallons per day and they pump to a maximum height of 500 feet.

New G. E. Bulletins.—The General Electric Company is issuing three new bulletins, one of which is descriptive of mercury arc rectifiers and bears the No. 4530. These devices are for the purpose of changing alternating current into direct current for charging storage batteries and other commercial purposes. They are comparatively inexpensive, requiring small floor space and have remarkably high efficiencies. The bulletin describes the theory and construction very clearly. Bulletin No. 4534 illustrates and describes horizontal shaft types of Curtis steam turbines, direct connected to generators [illegible] to 300 k. w. capacity. The third bulletin, No. 4533, is on the subject of the Wright demand indicators, which have been extensively adopted for determining the load factor, the maximum output of generators, transformers, feeders, etc. The theory of operation and general construction of these devices are clearly illustrated in the bulletin.

Flexible Compound.—The Flexible Compound Company, 3607 Haverford avenue, Philadelphia, is issuing several leaflets descriptive of this compound, which show its advantages in special classes of work. The compound is a perfect water-proof liquid, which, when mixed with paint or varnish, gives them flexibility and provides positive protection against the ravages of moisture, salt air, locomotive gases, etc. It prevents the peeling and cracking of paints and varnishes, will protect belts from dampness and renders iron and steel immune from the oxidizing effects of moisture or gases. It has excellent insulating properties for use in electrical work. The leaflets give directions for using and suggest many ways in which it will be found to be of great advantage.

Car Lighting by Electricity.—The Safety Car Heating & Lighting Company, 2 Rector street, New York, is issuing a very attractive, standard 9 x 12 in., catalog on the subject of electric appliances for car lighting. This company has developed a new system of electric car lighting, the current being generated by an axle driven dynamo, the effort being to obtain a system of substantial construction, simplicity of device and reliability of operation. In addition to the dynamo the system includes a dynamo regulator installed in the car, a lamp regulator installed under the car and a storage battery of 32 cells in boxes under the car, as well as the necessary fixtures, switches, lamps, etc. The dynamo is a four pole, shunt wound machine, designed for 50 amperes at 80 volts. It is driven from the axle by two belts, one at either end, either belt being sufficient, however, to do the work. The dynamo is suspended from a steel shaft hung just outside the end piece of the truck, toward the center of the car. An adjustable spring belt tightener is provided to give the proper tension on the belts. The system operates normally on 60 volts, which pressure is maintained, with a small variation, by a very simple design of regulator. A lamp regulator for controlling the voltage on the lamps, so that any lamp will give the same illumination irrespective of the number turned on in the circuit, or whether the battery is being charged or not, is provided. All the different parts of this apparatus are illustrated and their construction and operation is clearly described in this catalog. Several pages are also given up to illustrating a wide variety of electric fixtures for car lighting. Designs are shown for all conceivable purposes in single lamps, groups or chandeliers.

NOTES

Cincinnati Electrical Tool Company.—This company announces the opening of a western office and warehouse, for the sale of electric tools, at 18th and Rockland streets, Chicago, Ill. This office is under the management of Mr. Oscar B. Wodack.

Warner & Swasey Co.—This company, whose main office is at Cleveland, O., announces that it has opened a Chicago office in the Commercial National Bank Building, Adams and Clark streets, which will be under the management of Mr. E. B. Boye.

Cutler Hammer Mfg. Co.—This company, which some months ago announced its purchase of the Wirt Electric Company of Philadelphia, advises that it has consolidated the Wirt business with that of its New York plant at Park avenue and 130th street, where the manufacture of Wirt apparatus will be continued.

American Locomotive Company.—Among the orders recently received by this company are included 125 locomotives for the Harriman Lines, which order is made up of 30 mogul, 10 Atlantic type, 43 consolidation, 24 ten-wheel and 18 six-wheel switching engines. It has also received an order for a compound steam motor car for the C. R. I. & P. Railway.

Evening Classes at Columbia University.—During the year 1907-8 Columbia University offers twenty evening courses specially adapted to the needs of technical and professional workers. A full description of these courses is contained in the announcement of extension teaching, which may be obtained from the Director of Extension Teaching, addressed at the University.

Standard Roller Bearing Company.—Mr. C. D. Sternfels, formerly manager of the publicity department of the Arthur Koppel Company, has been appointed manager of the publicity department of the above company, with headquarters at the home office in Philadelphia. The company has recently increased its capital from $3,500,000 to $5,000,000. Large additions are being made to its plant and equipment, and an entirely new department is being established for the manufacture of roller bearings for trolley cars. It is stated that about $300 per year per car is saved by the use of roller bearings.

Publicity Engineer.—Mr. Walter B. Snow, who, for nearly twenty-five years, has been connected with the B. F. Sturtevant Company, announces that he is prepared to undertake work of any kind in the broad field of publicity for manufacturers of machinery and allied products. His regular service will cover the conduct of the publicity departments of a limited number of non-competitive plants and special service can be rendered to others in the form of general advertising, catalog making, technical writing and investigation. Mr. Snow has had a long and intimate acquaintance with engineering in general, and publicity in particular, and is specially well fitted to undertake this work. His office is at 170 Summer street, Boston, Mass.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

DECEMBER, 1907

STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

THE UNDERFRAME.

Synopsis.

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Historical.

That branch of transportation engineering which is exemplified by the most approved wooden railroad equipment and to a greater degree by the contemporaneous developments in steel or metals is a comparatively new and eminently thorough science.

Adaptability is one of the prominent characteristics of America and no matter to what degree the comforts and luxuries of travel be increased, just as surely do the people make use of them as their own and seemingly forget the yester-year. The efforts put forth for the betterment of transportation conditions have produced a stage of development which makes it difficult to conceive of equipment (within the life time of a man) which was so very primitive and from which our modern palaces of travel emanated.

Eighty years ago there were no railroads engaged in general operation in the world. The first railway passenger coach was run upon the Stockton and Darlington in 1825. There is naught about it which is particularly noteworthy, as it simply consisted of an old stage coach body which, having been removed from its running gear, was placed upon a timbered framework without even the customary leather carriage suspension. To this underframe pedestals were attached and the wheels and axles were taken from one of the company's coal cars. The whole underframe extended at both ends for a considerable distance with the evident intention of acting as a shield when the cars should come together in starting and stopping. It is interesting to note, in this connection, that the English carbuilders still separate the body and the underframe.

Five years later a little clap-boarded cabin appeared on the same road and was much less elegant than its predecessor. In this car only the side sills were extended for buffing and an entrance was placed between them at the rear.

The Baltimore and Ohio Railroad Company, in 1830, introduced practically the same car but made noticeable improvements in the seating arrangement and shortened the extension of the side sills to about half of that on the Stockton and Darlington. This car was likewise single ended and primarily intended for horse power.

The use of platforms and double entrances is shown in the Old Portage cars of 1835. The pedestals are still fastened directly to the underframe but springs have made their appearance. An iron railing guards the platform but is open in the center to permit of passage from car to car. The end sill was the strongest noticeable up to this time and all pulling was done from the center of it.

To Harlan and Hollingsworth, we believe, should be given the greatest amount of credit for having opened up the art of passenger car building, separate and distinct from freight car, house and carriage, or road vehicle construction. Their cars, the "Columbian" of 1836 and the "Tioga" of 1840, show an advanced effort to meet the growing conditions and provide additional comforts. The former of these cars was 32 feet long and 8 feet 6 inches wide. It was more commodious than the usual type then running, having seating capacity for 48 persons with a total dead weight of 18,000 pounds. The ratio of seating capacity to dead weight was thus 1 to 375. The latter car was 4 feet longer and was without doubt the most improved car in service up to that time. The Jeffersonville, Madison and Indianapolis Railroad Company were, at this period, running equipment much similar to our work trains as far as appearances go. In these cars is noticed the use of buffers or buffing blocks on either side of the snap coupler which was fastened directly to the platform sills in much the same manner as the Camden and Amboy coaches of two years later used link couplers. The sides of these (C. & A.) cars were paneled beneath each square window. The windows were of a single sash though directly above them, set in under the eaves, was a line of narrow sashes much like the modern upper deck lights.

Up to the year 1850 there were few cars built with any center sill construction between the bolsters. Usually dependence was placed on the floor and end sills to transfer all shocks to the sides of the car. Thus the underframe consisted principally of two strong side sills and a series of cross beams to carry all strains to them. Fig. 1, taken from an old C. and A. car of this period, which is still in existence, is a good illustration of this character of framing.

Though of comparatively recent development, a study of the evolution of car framing is complicated by a scarcity of available detail material. What is at hand is not sufficient to enable the credit for having produced the trend which settled the course of our present tendencies in design, being placed upon any designer or corps of designers with any large degree of assurance as to its justice. In 1862 the Pennsylvania Railroad authorized a design since known as the Pa, but then as "The New Standard Passenger Coach." This car was a most remarkable development for the day in which it appeared and the technical journals were lusty in its praise. Fig. 2 illustrates all the distinctive features of its underframe and comparison with Fig. 1 will show the change in ideas during the intervening twelve years.

Those cars which are now considered the most improved bear a striking resemblance in the character of underframing to this early type. The ideas thus brought forward were quickly adapted and it is safe to say that the real engineering associated with the framing and bracing of passenger equipment was accomplished before 1870 and the past 40 years have but seen the detail application of these ideas altered to suit the various demands of service. Figures 3, 4, 5 and 6 are but representative illustrations of ideas prevailing at various periods during the development of the modern standards. They are self explanatory and tell their own story of progression, largely in the line of provisions for load carrying and also to a smaller extent for service shock resistance. During this period the problems dealing with architecture, ventilation, heating, lighting, braking and coupling were given precedence.

Limitations Effecting Design.

The economic and social needs of the country which are ever increasing have become so insistent in the past few years that the alteration of this detail application of the early ideas can not be made radical enough to meet the requirements. Thus a reconstruction of the methods now in vogue, and which ought to be followed in the future, become necessary. To secure a satisfactory basis upon which to formulate the new theories, the problem should be made a general case of *knowing what are the demands of the service for which the vehicle is intended and then securing a just appreciation of the resistances and destructive forces which*

must be overcome for it to satisfactorily perform its desired function. This problem is complicated by sharp limitations such as: Lightness, Economy, Reliability, etc.

Lightness.—From a weight of 375 pounds per passenger in 1836 the dead load has increased to an excessive degree which reaches a maximum of 6,300 pounds in some of the modern buffet club smokers. The weights of the present wooden equipment are high. The practices of the Pullman Company, whose earliest cars were much heavier than any other class of equipment for passenger service, has no doubt had a tendency toward increasing the weights for all classes of service to secure a closer approximation toward uniform train strength. These weights should not be exceeded in the steel equipment by any appreciable amount, rather they should be reduced if this can be done in a manner consistent with proper reliability.

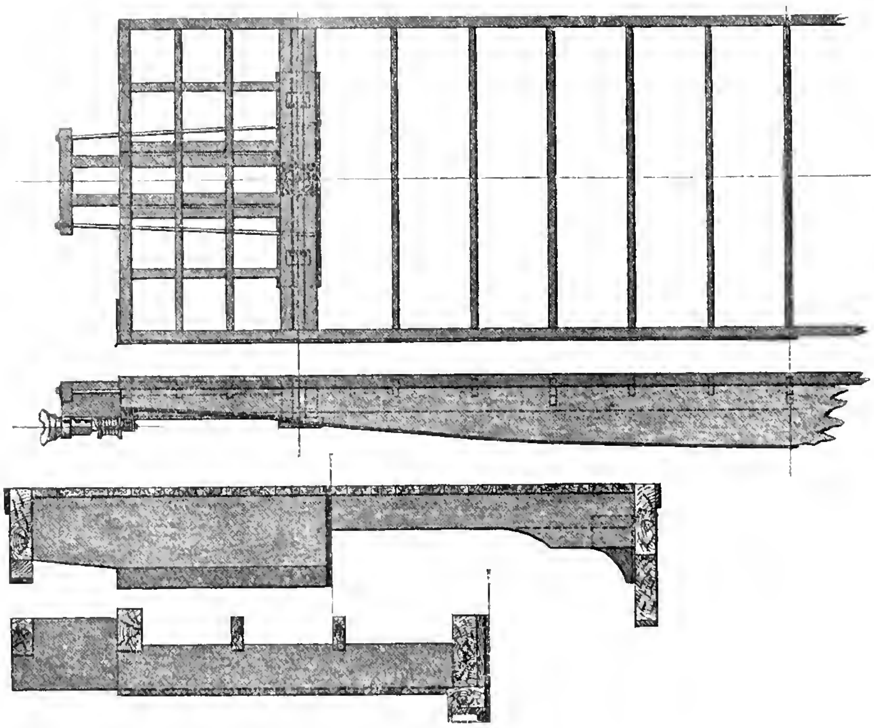


FIG. 1.

The question of weight directly affects the initial cost to a great degree. The tendency is now, more and more, toward basing the productive market price upon a sliding scale of costs plus a definite percentage of the costs as profits. This runs usually from 10 to 12 per cent., though keen competition and lack of orders work to make it lower. Included in the sliding scale of costs are the materials, direct or productive labor, the operative, and the administrative expenses. The second item, direct or productive labor, is governed by the amount of material and its disposition; the operating expenses are a function of the productive labor and will reach an amount somewhat over half as much. The administrative expenses are a function of all three factors, but to a much smaller degree than would be expected when it is considered that the larger salaries come usually under this head. In a well managed establishment this item should not exceed one twentieth of the combined material, productive labor and operating expenses. Thus the sliding scale of costs is essentially based upon two items, namely; the material and productive labor. For initial orders the cost, including profits, will be about 1.125 of the former and 1.875 of the latter. It is hardly possible at this stage of the art to determine the exact value of the ratio between the productive labor and the materials. This factor is so seriously affected by the character of the design making the labor portion higher or lower as the case may be. When the industry becomes more firmly established and the designs become more standardized the whole cost may be computed as a function of the weight of the material. The figures as given above will be lower on future orders of the same class due to the improvement of shop methods for rapid production, familiarity with the equipment and the cost of new dies, templates, and jigs being eliminated.

Economy.—This includes initial cost, cost of maintenance and repair, and cost of transportation. The first of these costs has been partially considered. The second needs a special article to do it justice, wherein should be included all factors covering the design and construction upon which the maintenance and repair bills are dependent. The longevity of steel equipment, for data concerning which we must go to Europe, presents these problems of minimum maintenance and repair costs for solution with more emphasis than they have come to our immediate predecessors. Trautwine estimates the life of the average passenger car at 16 years (18th ed., p. 865); this is somewhat low and especially so for the most modern equipment; but at its best the wooden construction can not compare with the results Mr. James Holden, Locomotive Superintendent of the Great Eastern Railway (England), noted as far back as 1898 concerning this point. According to a published interview he stated that he had used steel framed cars for thirty years and that cars built in 1873 still had years of service ahead of them. *Thus, if maintenance, repair and depreciation costs* are kept to a low figure, the long life of these cars will make them wonderfully economical even with a slightly increased initial cost.

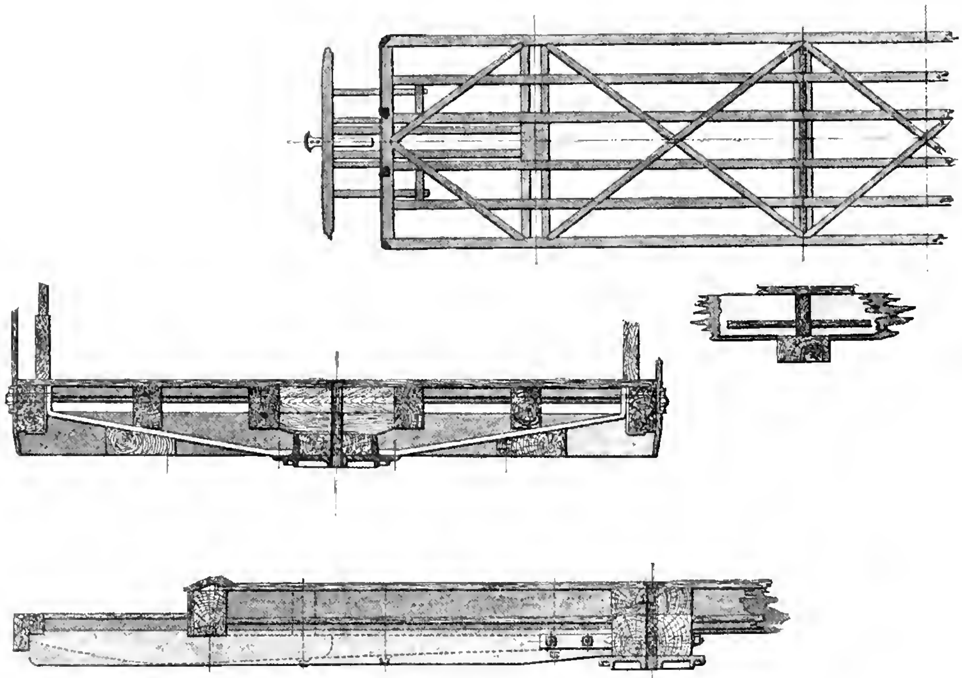


FIG. 2.

The last, transportation costs, is not as definite a subject, as it deals with the proper design of trucks and side bearings to give

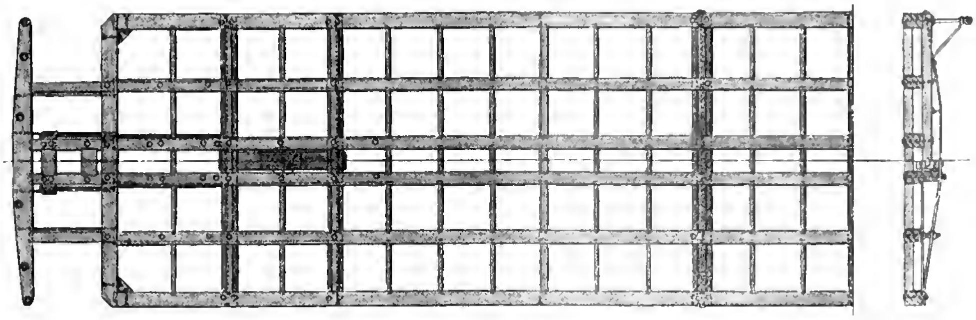


FIG. 5.

least haulage resistance, the proper design of couplers and coupler clearances so as not to bind and increase the flange friction in curving and in general the rideability of the car which directly influences travel and thus inversely reduces the revenues of transportation. The question of the real force of the value of excessive weight as affecting the cost of haulage is one upon which it is difficult to secure any adequate data. It would appear though that, since the cost of the crew and all other operating expenses, with the exception of the fuel and lubricants, are independent of the weight, a few thousand pounds more or less per car would not have much affect upon the costs of moving it when the sum total load is within the limits of the capabilities of the prime mover. This seems to be true so long as we neglect the factor of speed. Rapid acceleration and retardation, however, demand the lowest weight consistent with comfort and safety.

Reliability.—Safety and strength with economy, are the ends sought after by the introduction of metal bolsters, metal

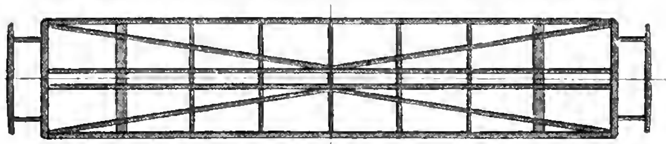


FIG. 3.

platforms, full vestibules, rod and plate trusses, metal underframes, increased buffing strengths and fireproofing precautions. These qualities must be furthered in any progressive steel design.

General.—Aside from the foregoing limitations surrounding any intended design, principles of comfort, convenience, sanitation and car esthetics have also to be conserved. Not to do so would be a retrogression which would tend to lessen the burden of travel. These latter qualities or principles do not have as direct a bearing upon the character of the framing as the necessary requirements of reliability and the economics of production and operation, but the real merit of any design and the extreme care manifested in its completion will be shown by the disposition of the framing so as to secure a maximum of these desirable ends with a minimum of material and productive labor, and the utilization of each detail of the design to perform a multiplicity

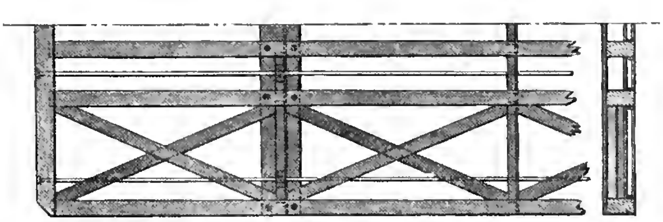


FIG. 4.

of functions wherever possible, with each proportioned to its required service. The time element involved in the designing of such equipment, by the variation of conditions in the arrangement and framing in order to note to just what degree the product can be simplified, is well repaid in the final result. The centralization of functions in one unit to eliminate numerous separate parts should, however, be solved with a regard for the facility for repairs. Other conditions being equal, the simplest design is the best and displays the best thought.

Summary.—The car shortage is now being felt in passenger service as well as freight and the necessity for large orders in the immediate future, especially those for tunnel operation, warrants the building of equipment of the highest class. Since 1902 American designers have been developing those ideas in steel equipment which, though not new nor brought before the public now for the first time, are still of the highest value and worth. That they have not been used years ago is simply a question of the motive power balance sheet. Now, employing engineering practices of the best type and taking full advantage of the cost of raw constructive materials, the problem is ripe. It is hardly possible to place too much emphasis upon the fact that with the utilization of a more efficient material the new theories should bear no evidence of an unwarranted prejudice in favor of the wooden design else the best possible results be not forthcoming. Thus the problem should involve both theoretical and practical elements and steer an intermediate course, the one depending upon the other. The problem of mathematics should be exactingly criticized in the light of past experience, but on the other hand practice should not be followed contrary to the fundamental laws of mechanics, a state of affairs which can readily be noticed in some few designs now before the railway world.

The more extended the experience possessed with equipment, the more evident does it become that the unexpected usually happens. There are few cases in which the cars have taken a collision alike even though in the same train and built from the same design. With the present type of wooden framing it is an impossibility to trace the mode of transference of the strains throughout the car and arrive at a just approximation of the stresses in the various members. This would indicate that an underframe should be designed, so as to take up the shocks and service strains imposed on it, from data derived by experiments and calculations, thereby securing a form that can be better proportioned to suit the requirements. This is a possibility and in the following, after these shocks and strains imposed by service have been determined, it will be shown both graphically and analytically how this can be done with a minimum weight.

The Service Demands as Affecting the Character of the Underframe.

Motive power designers long engaged upon the problems associated with the designing and building of cars for steam service have, during the past few years, been called upon to take into

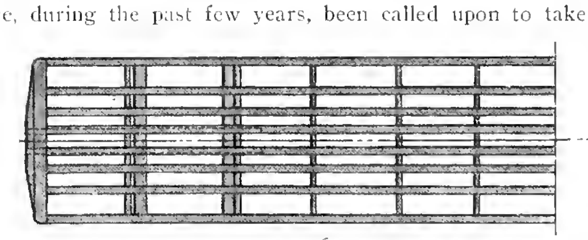


FIG. 6.

consideration the vast strides that electricity has been making for recognition as a successful competitor with steam for motive power upon its own ground. This advent, which is quite general for certain classes of service, has opened up two new types of train propulsion which must be adequately taken care of in present equipment. The problem for electric locomotive propulsion approaches closely to that for steam, while the multiple unit train control demands quite different treatment. Thus, also, what is a necessity in long distance heavy express service, no matter the choice of motive power, must be radically modified

to suitably meet the requirements for suburban and metropolitan service where choice of motive power is generally restricted by franchise to electricity. After careful consideration of these probable changes the designer with real ability displays it to the greatest degree by the means and possibilities he has taken to provide for the problems which we can now recognize as coming in the near future. The one great problem is the probable electrification of the very roads for which steam equipment is now under construction. This leads at once to the conclusion that for all such lines this equipment should be so designed that it will be susceptible of expeditious and economical modification for either type of electric control.

The multiple unit electrical control demands the most if not all the consideration. The character of the motive power unit or its probable change is thus one of the first considerations of the designer and will be dealt with in detail for each main class of service.

Service Classification of Equipment.

In general all car equipment can, for purposes of study, be grouped under two general types, the one should include all cars destined to be run in trains and the other all equipment run as separate motor units. This classification can then be extended much as shown in the following diagram:

Passenger Equipment.
- I. Train Service Equip.
  - 1. Trunk Line.
    - a. Express.
    - b. Accommodation.
  - 2. Suburban.
- II. Motor Cars.

For each of these classes, express, accommodation, suburban and motor, should be included all cars which are equipped to run regularly in passenger trains. These cars may not all carry passengers, but they have all their leading features in common and should present a uniform appearance and possess a uniform strength with all the other equipment of its class. Thus the express service would include coaches, baggage, postal, express, combination, parlor, sleeping, dining and miscellaneous cars. The last would include cars specially arranged inside and any other equipment which may happen to be run in the same train.

The accommodation train is seldom made up of any equipment other than the coaches, combination, and baggage cars.

The motor car service would cover the range of motive powers used for separate car running, such as gasoline, steam and electric.

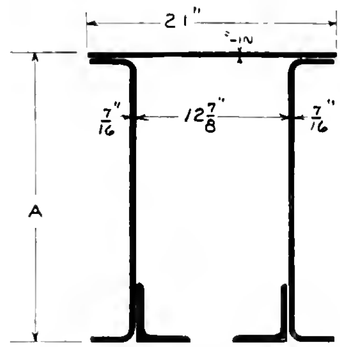
Trunk Line Operation.

Express Service.—From present indications it is safe to assume that through express trains will continue to be operated by steam for fifteen to twenty years to come or until such time as the electrical engineers can so perfect their systems of transportation and control and the detail apparatus that the economies effected by changing from the existing methods would not only equal the present revenue but be sufficient beyond this to pay the charges for interest and depreciation on the cost of the new installation. The loss due to scrapping the steam equipment would be startling. Even were it admitted that the cost of transportation was smaller for electric than steam, this saving would be more than offset by the increase in the dividends upon the extra capitalization. In order that the change should pay it [illegible] becomes imperative that the long distance patronage of the [illegible] be [illegible] much augmented by the innovation. This is a matter [illegible] leaders in the passenger traffic departments affirm it cannot be done. The possibility of greatly improving the steam locomotive tends to put the day of probable change still further distant, and when it does come all signs indicate that it will be in the form of electric locomotives. Hence for trunk line equipment operating under normal conditions the question of multiple unit control need not be considered as a factor which would affect the character of the design of the underframe. This means that, for this class of car equipment, with a floor limit of 52 to 53 inches above the rail a central backbone 18 in. to 20 in. deep can be secured over the truck center plate and a depth between the trucks limited only by track clearance.

Strength and Reliability Factors.

The requirements for strength of car equipment is a subject which has been singularly neglected by the engineering societies and publications.

Though various ideas have been expressed, various tests been made and figures given for the value of end shocks, there is nothing uniformly definite about them. Nearly every builder or designer displays some pet theory in his productions which stamp them with his individuality. This is more clearly evidenced in the detail workings but very often can be traced in the general framing. An inspection of the table of center sill sections (Table No. 1) will show that there is a great diversity of opinion as to what is required to sustain the severe end shocks and provide for load carrying. This lack of uniformity in the underframing is a bad feature on account of the great difference in resisting qualities of similar service vehicles. The lighter and weaker sections will no doubt sustain the stresses imposed by load carrying, but rough handling and collisions will reveal their weakness. In considering the table mentioned it is necessary



A = 10.5" OVER TRUCK C'T'RS
A = 24.5" AT C'T'R OF CAR
FIG. 7.

that the radius of gyration and modulus of resistance should govern as noted farther on in the discussion. It is proper, also, to compare only those underframes which are intended for the same service.

Some authorities in car equipment have expressed the idea, that the specifications which govern the design and construction of cars should have a clause incorporated in them which would require a definite sectional area for the center sills. There are so many factors which tend to increase or decrease the stresses in these sills that such a method is hardly feasible. To make it practical would require a ruinous number of amendments providing for the variation in live and dead load transference and the eccentricity of draft and buffer attachment.

It is possible, nevertheless, to specify a minimum area for certain classes of service based upon the hazard of such operation. From an examination of the latest types of freight cars with a central buffing column, we note that the sectional area of this column over the truck centers is 38 square inches and $40\frac{1}{2}$ square inches in the center of the car (the sills being fish bellied). This area is disposed as shown in Fig. 7. For all classes of service in which there is a possibility of collision with freight trains of such cars, this area (38 square inches) then should be specified as a minimum allowable section. Any increase above this would make the passenger cars just so much stronger than any rolling equipment on the road. We are not aware, however, of this idea ever having been carried out in ordering such equipment.

Other designers in drafting their specifications and cars have seemingly ignored the question of providing for these shocks directly. Starting with the idea that in a span of such length the

deflection was the governing criterion, the problem has first been solved as one of stiffness and then investigated for strength. Both of these calculations included the static loads only, and finding that the fiber stresses from these loads were less than the elastic limit of the structural materials used, the structure was deemed amply able to take care of the end shocks. To make sure of these shocks being transferred over all the longitudinal sills heavy plates and end castings have been worked into the detail underframing.

The conditions necessary to make the side sills or girders carry the end shock (which are noted in the underframe discussion) have not otherwise been fulfilled in any design thus far given publicity and calculated as indicated above.

The laws for stiffness of beams are much different than those for strength. The stiffness of a beam is measured by the load it can carry with a given deflection. The strength of a beam is measured by the load it can carry with a given fiber stress. The stiffness varies directly as the coefficient of elasticity, the moment of inertia, and inversely as the cube of the length, while the strength varies directly as the moment of inertia and inversely as the length. Putting these in the shape of formulæ:

For stiffness

$$P = \frac{EId}{L^3} \times K_1.$$

For strength

$$P = \frac{SI}{Lc} \times K_2.$$

Where E = coefficient of elasticity;
I = moment of inertia;
d = deflection;
L = length in inches;
S = working stress;
c = distance from neutral axis to most extreme fiber and K_1 and K_2 are constants depending upon the character of the loading.

No	ROAD	SERVICE STM	SERVICE ELC	CLASS	FORM	AREA OF SECTION A SQ. IN.	MOM. OF INERTIA AXIS X-X I IN⁴	SEC. MOD. AXIS X-X $\frac{I}{c}$ IN³	RAD. GYR. $r=\sqrt{\frac{I}{A}}$ r IN	SEAT. CAP'Y	WT. OF CAR BODY LBS.	WT. PER PASSENG'R LBS.	REFERENCE A.E & R.R. JOUR
1	ILL. CENTRAL	"		PASS.	3	12.62	169.8	37.8	3.67	100	61,400	614	6-03, 9-03, 10-03
2	INT'R. RAPID TR'NS		"	"	3	7.2	27.2	10.8	1.94	52	27,000	519	3-03, 10-04
2_1	" " "		"	"		25.5	87.02	34.8	1.84				" "
2_2	N.Y. SUBWAY		"	"	1	10.14	52.4	17.4	2.27	52	34,000		" "
3	70 FT. (G.I. KING)	"		"	3	38.7	1264.68	182.49	5.71				..
4	SOUTHERN	"		"	3	34.875	1702.02	133.91	6.97				7-06.
5	LONG ISLAND		"	"	1	10.14	52.4	17.4	2.27	52	38,278	734	9-06
6	SANTA FE	"		POSTAL	3	31.	2830.8	220.64	9.55				10-06
7	SOUTH. PACIFIC	"		PASS.	3	18.52	431.6	72.	4.83	70	75,550	1,079	1-07
8	LONG ISLAND	"		"	1	17.64	268.4	53.6	3.90	72	72,500	1,007	2-07
9	N.Y.C. & H.R.R.R.		"	"	1	10.66	113.8	28.4	3.27	64	67,170	1,049	3-07
10	P.R.R. (1651)	"		"	2	55.86	3645.14	383.69	8.07	72	78,450	1,089	6-07
11	P.R.R. (6546)	"		POSTAL	2	"	"	"	"		89,500		4-07, 6-07
12	P.R.R (70 FT)	"		PASS.	2	50.	3202.98	337.15	8.	88	88,400	1,004	6-07, 7-07
13	P.R.R (60 FT)	"		BAGGAGE	2	"	"	"	"		67,900		7-07
14	P.R.R. (70 FT)	"		DINING	2	•	"	•	"	30	101,000	3,366	7-07
15	SOUTH. PACIFIC	"		POSTAL	3	18.52	431.6	72.	4.83				6-07, 7-07
16	UNION PACIFIC	"		"	3	"	"	"	"				6-07, 7-07
17	ERIE	"		"		36.03	2527.92	259.79	9.01				
18	N.Y., N.H. & H.RR.	"		"		"	"	"	"				
19	PULLMAN	"		SLEEPING		34.77	783.63	98.56	4.74	30	†125,000	4,166	4-07
20	P.R.R. (P53)	"		PASS.	2	32.24	2038.17	214.54	7.7	64	64,900	1,004	
21	C.I. & L.R.R.	"		COMBINED	3	10.66	113.8	28.4	3.27	16			
22	LONG ISLAND		"	PASS.	2	24.32	433.27	82.53	3.7	72	50,000	694	7-07

For reference to No. 3 see *M. C. B. Proc.*, Vol. 38, and to No. 21 see *R. R. Gazette*, 1903, p. 452. † Estimated.

TABLE NO. I.

It is possible to equate the two values of P and secure a relation between S and d which can be used in the column formulæ to solve the center sills. To consider the center sills as a beam loaded both uniformly and with concentrated forces as well as an eccentric end load is probably the most exact method. To properly solve this problem it is necessary that the number, value and disposition of the various loads be known and the equation for the elastic curve expressing those conditions found and integrated twice to find the value of the deflection. Then equate this to the value of the deflection formulæ which we have previously made to express a relation between strength and stiffness. This can be accomplished with great ease graphically and the graphic curve indicates a very close approximation which is shown later on.

End Shock.—It will be noted that an assumed end shock is necessary in the above method. The assumption of this is the nucleus of the method we believe should be used to cover this question in the specifications.

From dynamometer tests made upon the Lake Shore and Michigan Southern Railway (1902), it is shown that with careful handling the pulling strains will reach 50,000 pounds, and 100,000 pounds with rough service. For buffing the former strains will be at least doubled, and tripled for the latter. This figure of 300,000 pounds is considered low by the prominent steel car companies and railroad officials independently designing their own equipment. These men are now introducing buffers and draft gears with a combined capacity of over that amount. From an investigation of the repair yards for steel cars following the discussion of this subject in the Pittsburg Railway Club (1905) we believe the best requirement for trunk line cars to be,—*those portions of the underframe which are designed to resist end*

shocks must be fashioned to withstand a static tensile load of 150,000 pounds for pulling and a static compressive load of 500,000 pounds for buffing and that the stresses occasioned by these loads when combined with the stresses due to dead and live lading shall not total more than the elastic limit of the material. This limit should also be given in the specifications.

This value of 500,000 is high for even severe service handling and especially so for the passenger service, but the stress is likewise allowed to reach a good figure.

The net area of tension flanges or beams should be taken when considering the stresses for a final investigation of the center sills and for the compressive flanges or beams this allowable stress should be modified so as to introduce the relation between the length of the column (L) and the radius of gyration (r) of the column section. The formula of the American Railway Engineering and Maintenance of Way Association shows that the stress should be reduced by $70\frac{L}{r}$. Hence for allowable compressive unit strains at the shock considered, it should not be greater than. elastic limit—$70\frac{L}{r}$

The net area in the compression flanges need not be considered if the inspection is rigid enough to secure first-class workmanship as in that case the rivets may be assumed to completely fill the holes.

It is a difficult matter to locate any line of demarkation between severe service and operating collisions. The above specification clause would take care of most of the road accidents and beyond that afford additional, though weakening, strength up to the ultimate. The deflection of these sills must be taken care of and prevented in the best manner possible, for when a compression column fails, as these would, by lateral deflection the elastic limit strength and the stiffness are the determining elements of the collapse rather than the ultimate strength.

The arching of the center sills in riveting them up is a good feature in this connection. They should have sufficient upward camber so that when the weight of superstructure is placed upon them, the neutral axis will be forced down to a perfectly horizontal line. The method of fastening the intermediate cantilevers to the longitudinal sills should be such that if an excessive shock tends to produce a dangerous deflection, the center sills can call upon the side sills to work closer to their elastic limit and help sustain a part of the flexural load caused by such deflection. The use of truss rods are not of much avail because with an underhung draft gear this excessive load would put the rods in compression.

In a number of earlier designs during the transition period flitched (composite) girders of wood and steel were used for this purpose, the idea being that the iron should reinforce the wooden beams. This, however, did not work successfully since, due to the difference in the moduli of elasticity, the steel took all the load. The cars were not designed with this intention and they failed in service. Cars were later designed, after such failure, and the wood simply used for fastening purposes, then the area of wood was gradually reduced to the point of elimination. This accounts for some steel cars which are an accurate counterpart of the old wooden framing.

Mr. G. R. Henderson gives as a requirement in his specifications for freight cars, ". . . . . . . the center sills and draft attachments must be proportioned for a force of 100,000 pounds pulling, and 200,000 pounds buffing, and strains due to either or both the horizontal forces and the vertical loading combined must not exceed 12,000 pounds per square inch in tension and $12{,}000 - 70\frac{L}{r}$ in compression, where L = length and r = radius of gyration, both in inches." If it be assumed that Mr. Henderson's and the author's specifications be applied to the same car it would mean that for the same stress to be acting, the elastic limit would be 30,000 pounds per sq. in. This a good average figure for structural steel, a number of the prominent engineering firms as well as city building laws placing the limit from 3,000 to 5,000 pounds higher and a few railroads 2,000 lower.

If further investigation and tests reveal the assumed relation between the end shock of 500,000 pounds and the elastic limit of 30,000 pounds per square inch to require too high an efficiency from the underframe we would favor raising the 500,000 to the necessary value for a safety factor and preserving the specified elastic limit.

The statement that the stresses should not exceed a specified limit of, say, 12,000 or 15,000 pounds per square inch does not in reality secure the uniformity in strength that is desired. At first thought it would seem as though the solution was accomplished, but, unless the ultimate strength or elastic limit be also specified or the allowable stress be a certain function of the elastic limit, it is not so. Since the elastic limit may vary between 23,000 and 37,000 the final strength will vary in the same ratio even though the stresses do not exceed the specified limit. To reduce the problem to one of a definite shock with a definite elastic limit strength is a great step in the direction of scientific accuracy.

Vertical Loading.—Having secured data upon which to base the horizontal loads the next factors to be considered are those acting in the vertical planes of the center and side sills which, combined with the former, denote the size sections which must be used to stand up to the service. The graphical analysis as well as the analytical discussion depends upon a careful selection of these constants for their accuracy.

As a means to definitely determine the value of these constants and thereby secure a just appreciation of the distribution of the weights of superstructure and lading we consider a section of the car, as shown by Fig. 8, a unit in length. The side sill will then each carry the weight of the superstructure one foot long and one-fourth the distributed per foot weight of seat and passenger load.

To determine the weight of the vestibule, which is really a concentrated load on the center sill overhanging the truck center, we have, by assuming—

W = total weight of car body + passengers, allowing 50% for overload in the latter.
W_1 = weight of vestibule end.
b = distance between end sills.
w = uniform weight per foot length.

$$W = 2W_1 + wb$$

$$\text{or } W_1 = \frac{W - wb}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Therefore, for ease in securing the constants necessary in determining the existing stresses and the proper distribution of the various loads, we have endeavored to show in Table I. all the cars, both steel and composite, that have appeared in the various technical papers from the time this form of car made its first appearance up to the present. It was found necessary, owing to the wide range of service and peculiarities of design both in center and side sill construction, to compile the properties of these designs for comparison, as to strength and stiffness.

From the seating capacity and weight of car body, if for passenger service, and from the weight of car body and capacity for baggage, the various loads per foot of length are found to be as follows for the various vehicles:

For Electric Service:
w = 950 lbs.

For Steam Service:
w = 1,325 lbs. (Passenger).
= 1,400 " (Dining).
= 1,500 " (Sleeper).
= 1,600 " (Baggage).

The above constants, which are a mean of the various vehicles, can be used in determining the weight of car body plus a 50 per cent. passenger overload when the length over the buffers is used as a multiplier. They should neither be used in an assumption for determining the weight of the car body proper, between end sills, nor in ascertaining the weight of overhanging vestibule load, the former of which, namely w, as noted in the following paragraph is higher and the latter lower per foot than the value tabulated.

As a means in securing this data we have made a few assumptions: 1st, that the weight of vestibule equals 5,400 lbs., which value when substituted in equation (1) will give the uniform

weight per foot of length somewhat higher than those given, the latter of which should be used.

Our second assumption is that the center sills take 550 lbs. per foot length, while the side sills take the difference between the above weight and the constant found by our first assumption, which we found to be 1,380 lbs. per foot of length; this would give the side sills 830 lbs. or 415 lbs. per foot of length each. These values then we intend to consider in following calculations.

Trunk Line Accommodation Service.

This branch of main line operation offers a more inviting field for the use of electricity than the express service. There are some roads already running electric trains over the existing steam right of way with success. To reach its greatest development trains should be run at shorter headway and by making the schedules attractive increase the patronage to a paying degree. This can be done, though it will be a difficult matter when thus run upon a busy steam (express) line to keep the services from interfering. There is a great probability that some time in the future the accommodation service will be run on separate tracks with electricity as a motive power. This service naturally runs

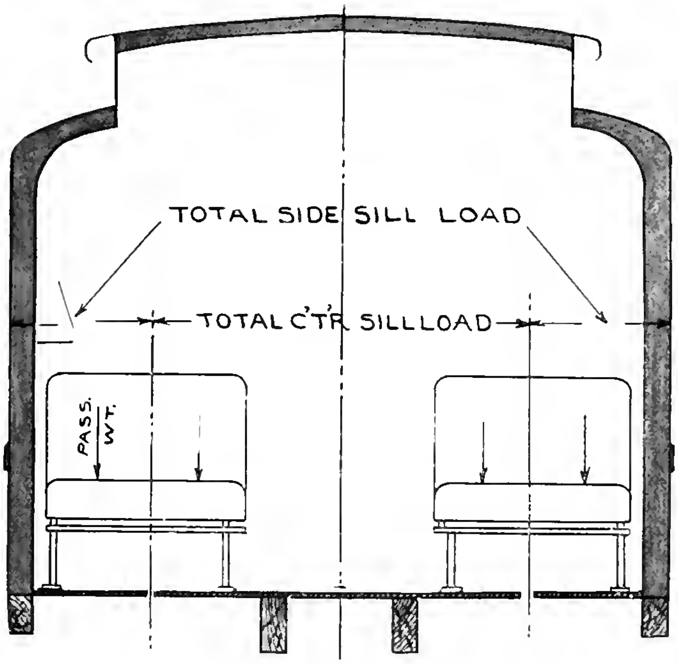


FIG. 8.

much into the province of what is properly known as suburban running, with the advantage that the travel is, as a rule, neither so congested nor so periodic. The disadvantage holds that they must have their framework designed to take the same shocks and loads as the express service if they use the same right of way, otherwise they can be built according to the data covering the suburban equipment.

Suburban and Metropolitan Service.

This service with few exceptions merits the consideration of a probable use of multiple unit train control and its effect upon the framing. Here the problem is much different since the cars, because of the character of the traffic, which is periodically congested, must be made lighter and shorter and capable of quickly discharging their passengers and filling up again. Tunnels, subway and surface lines running trains through cities and into terminals at short headway with numerous stops are being compelled to electrify. Here it can be economically accomplished.

This class of service must have an underframe which is elevated sufficiently to allow the placing of motors underneath the sills which for the larger class of machines means from 40 to 41 inches. The depth of the underframe is thus restricted, since it is not advisable to have the floor more than 53 inches above the rail. This limitation is not a serious difficulty, since the character of the shocks from the service imposed are not so severe. For steam or electric locomotive service this follows from the lightness of the equipment and it is much less for individual car control. Also the probability of an encounter with heavy fast moving freights is more remote. The end shocks in such service will not total more than 80 per cent. of those for express running, so that the value of 500,000 pounds should be replaced by 400,000 pounds and the elastic limit strength, together with the necessity of keeping the total stresses within it, will apply to suburban equipment the same as for express.

It is very desirable that throughout all these types of equipment the principles of uniformity, making for extensive interchangeability and standardization be kept well in view. These will be felt in a manner least thought of, that of increased safety to the public; since the facility with which repairs can be made makes it certain that they will be taken care of promptly and before an accident occurs. This idea has been expressed as applying to electric motor cars, but is true of every class of equipment.

The weight of 950 pounds per foot, which is an average of cars now built including vestibules and lading as noted before, should be used in calculating w for designing this type of car. The vestibule weights will be as high as for the express due to the increased length necessary to properly handle the traffic with the minimum loss of time at station stops.

The separate center and side sill weights should be the same portion of 950 as 550 is of 1,325, which we find to hold good for express service.

General Discussion of Underframe.

The design of car framing has been likened to and in many cases is made a problem of bridge engineering pure and simple. This is a fallacy at the present day; there was a time when cars were intended for separate running at slow speeds when the forces necessary to be considered were simply those of the dead load of the car body and the live loading of passengers and baggage. The basis of calculation was then found in these weights carried; now the strains from service handling introduce stresses beyond what these former forces will reach and the problem is modified accordingly.

The superstructure cannot be made of a strength equal to that of the underframe and keep within the prescribed limits. It must withstand, however, the stresses occasioned by the inertia forces during coupling or braking. It must be a slightly elastic enclosure capable of being rolled over without collapse; and though yielding to a very small degree, it must not bind windows and doors under service conditions.

The framing then should not be dependent upon the roof and side plates for strength, but the functions of these details should be for finish and an aid to the preservation of post and carline alignment. Truss rods as well as any other tieing liable to entanglement in wreckage should be done away with and the sides made strong enough to be load carriers between transverse supports. These transverse supports should be placed so that the weights of the superstructure and lading are transferred to the center sills so as to fully utilize the metal in them necessary for buffing. The underframe should, first of all, then be composed of centrally located longitudinal resisting bodies in a single column form, which is strong enough to prevent any relative displacement of its ends under ordinary service conditions.

The side girder construction designed for load carrying is not of a character suitable for end shock absorption. In order that these girders should help in this service it would be necessary to have an end construction which rigidly connects the ends of all longitudinal stringers together, which is a matter of great difficulty. This end construction to transmit the end load to the side girders must have no appreciable deflection and then at its best would apply this strain at a large eccentricity. This means that the first effect would be to dangerously stress the girder in a vertical plane if it were heavily loaded already and the cross ties were strong enough and properly placed. The sides as a rule are heavily loaded and the ties are not right for this use. To satisfactorily serve such a purpose these ties between center and side sills would have to be capable in both tension and compression; they must be attached to the sills with great care so

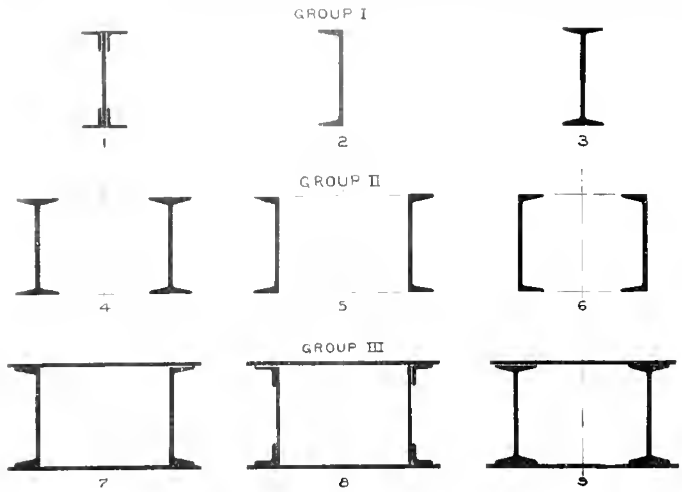


FIG. 9.

as to avoid the creation of eccentric secondary stresses; their end attachments must be rigid at both center and side sills; and they must be placed close enough together to reduce the section of sill between them to the condition of a pure compression piece.

These conditions are not possible of fulfilment with a low weight and the center sills should be considered as taking all of the service end shocks. Thus the center sills should be of the most economical form for compression members. This member must sustain a uniform flexural load, an eccentric end shock and, depending upon whether the center or side sills are load carriers, various concentrated loads at the transverse cantilevers.

The economical form of such a member depends upon the cost of the material and the manufacturing of that material into the shape most suitable to the detail design. More than all else does the economical form of this column depend upon its stiffness and efficiency as a strut. From an examination of column formulæ it is easily noticed that this efficiency is governed by the radius of gyration of the given section when the lengths and end construction are given and that, "the greater the least radius of gyration the less the required area." The ratio between these radii for the sections illustrated in Fig. 9 are as 2, 3 and 4 for the 3 groups respectively. The value of the cover plates to take up the bending moments produced by an eccentric application of the load can not be neglected. When the stiffness and strength of the center sills in their capacity as a beam with overhanging ends is considered the value of the sections in group III. is further emphasized

Consider two center girders of equal area and equal weight. If the moment of inertia and modulus of resistance be unity for the sections in group II., they will be more than three times as large for those of group III.

Thus for a given weight an underframe is but little more than 1/3 as strong as it should be when formed of simple I and channel sections.

The change from wood to steel as a constructive element is a measure destined to broaden the limitations surrounding car design. With wood these bounds are evidenced by the inability of providing a sufficiently strong and light central backbone to which can be transmitted the outer lading for our longer cars.

The three following ratios have been frequently used to show that for equal weights steel and wood are of equal strengths:

1. Ratio of weights $\frac{\text{Steel}}{\text{Wood}} = \frac{480.6}{38.08} = \frac{12}{1}$

2. Ratio of crushing strengths $= \frac{55{,}000}{5{,}000} = \frac{11}{1}$

3. Ratio of tensile strength $= \frac{55{,}000}{7{,}000} = \frac{8}{1}$

Did we have the space necessary it would be impossible from the standpoint of dead weight and economy to place wooden stringers of a depth or breadth to equal the reliability of such center sills as the most reliable noted in Table 1.

These ratios would indicate that for tension only, to secure an equal strength we would need but ¾ the weight of wood as of steel while for compression the weights should be approximately equal.

These results can be accepted as holding only where the disposition of the material is the same in both cases, but when a change to a more efficient material is made the field of possible arrangement alters the matter so that, by properly disposing the material into the form of commercial shapes and utilizing plates to form box girders, a marked increase in strength is secured without a corresponding increase in weight. This is especially true when the depth is limited as in the case under consideration. When the limitations governing the physical form in which wood can be used and its fixed strength are considered, it does not then suffice to say that equal weights provide equal strength.

The vertical plane couplers seem to be unable to preserve the proper alignment of the platforms and so the post connections for the end of the car with the underframe, must be of sufficient strength to enable the one car to resist the tendency of its being telescoped by the ram on the end of the overriding platform. These rams (end castings or other steel construction) should also be formed large enough to prevent a partial side telescope in the event of the couplers breaking and the transverse alignment being destroyed. They should also be so shaped that their form tends to throw one car out of range of the other in the case last mentioned.

The attachment of the draft gear is a detail which merits careful consideration. Its location with reference to the neutral axis of the center sills has a great bearing upon the stresses occasioned by the shocks transmitted through it. These stresses can be much increased or diminished by the disposition made of the draft gear or, since the height of the coupler is fixed, by the relative positions of the (axes of the) imposing and resisting forces.

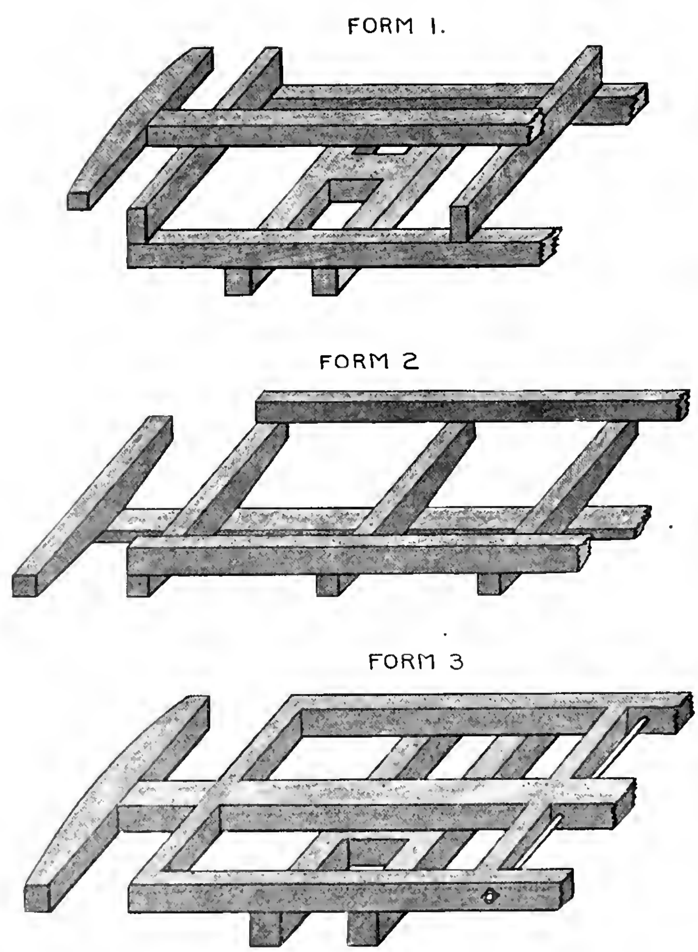


FIG. 10.

Arrangement of Underframe Members.

The strains which are liable to be imposed upon the underframe having been determined, the next step is to enquire into the possible methods of transferring these forces to the center-plates. The necessity for strong center sill construction for pulling and buffing has been dealt with in general as well as the impracticability of creating side girders to help sustain such forces. There remains to be considered the carrying of the live and dead loads. Starting at the center plate it is evident that it may receive its load: first, directly from the side sills; second, directly from the center sills; third, from both center and side sills.

The three perspective forms as illustrated, Fig. 10, are intended to clearly show the essentials of these three classes of load transferrence. They do not purport to show any detail design. Theoretically the first form is not found in practice as it would mean that there were no center sills whatever and that the whole superstructure and floor loads were transferred to the side sills and thence through the bolster to the center plate. The practical working out of this form shows a center sill which is weaker than the side girder and as a result, is in effect hung up to the sides at intermediate points between and beyond the bolster. Then the bolster gets all its load from the side sills, with the exception of the center floor load in the immediate bolster vicinity. The bolster with weak center sills is then the governing feature of this form.

The second form is readily known by the absence of any bolster. This is its distinguishing characteristic. In this case the static lading is all transferred at various intermediate points to the center sills which in turn put it directly upon the center plates which are riveted to them. This type presupposes a strong center sill and may make use of a weaker side girder. There is but one road so far as we know using this form of under body.

The third form is characteristic of a majority of all the equipment in service. Here all sills carry load to a bolster.

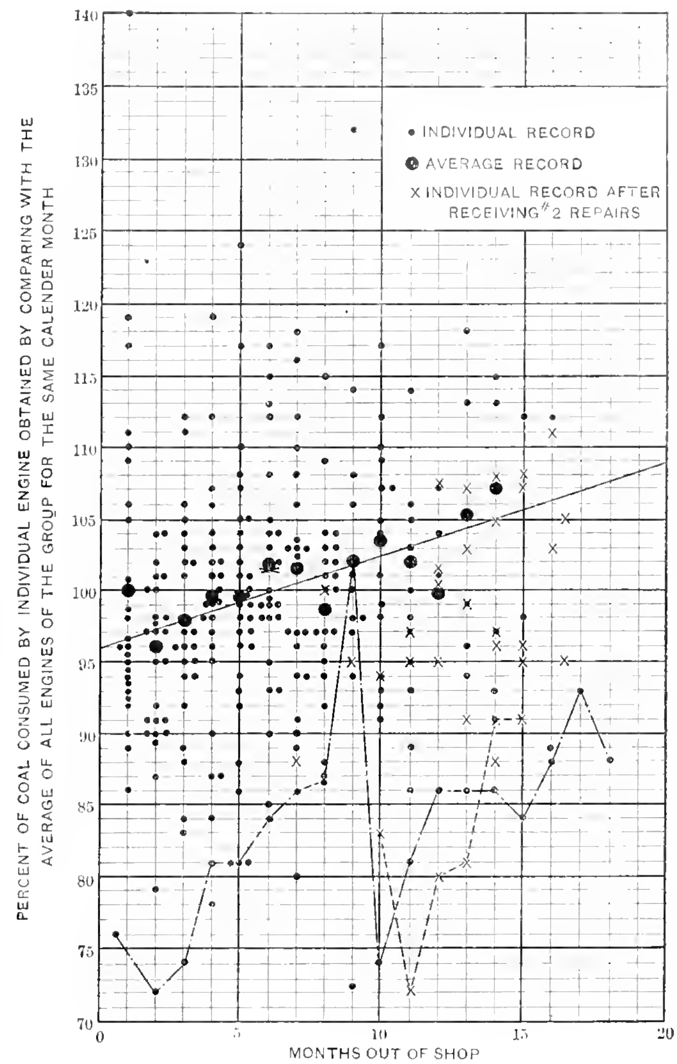
In all of these forms the side sills should be capable of sustaining the load between their transverse supports. These forms are quite general and are susceptible of much change so that the one seems to overlap the other. This confusion is readily cleared away when the relative stiffnesses of the side and center girders are known for the load they are to carry respectively.

The second form lends itself particularly to those cars which have side doors such as the postal and the baggage types. A support may be placed directly under the aperture for load transference to the center sills and the side will not need to be strengthened by fish-bellied sills, truss rods, or a framed construction carrying the strain up to the eaves and over the door. The advantage accruing from the most improved ideas of interchangeability and standardization would argue that the same construction for these reasons, if for no others, should be followed in all equipment. For end shocks up to one-quarter of the assumed maximum it is possible to construct the first two forms of cars at about the same cost. When the end shocks reach a higher figure and approach 400,000 to 500,000 pounds the center girder of the first form must be increased considerably beyond what would normally be required. There is then a surplus of material in this form, when designed for heavy duty, beyond what the service warrants and this fact makes the first more expensive than the second form.

THE EFFECT OF AGE ON THE COAL CONSUMPTION OF LOCOMOTIVES.

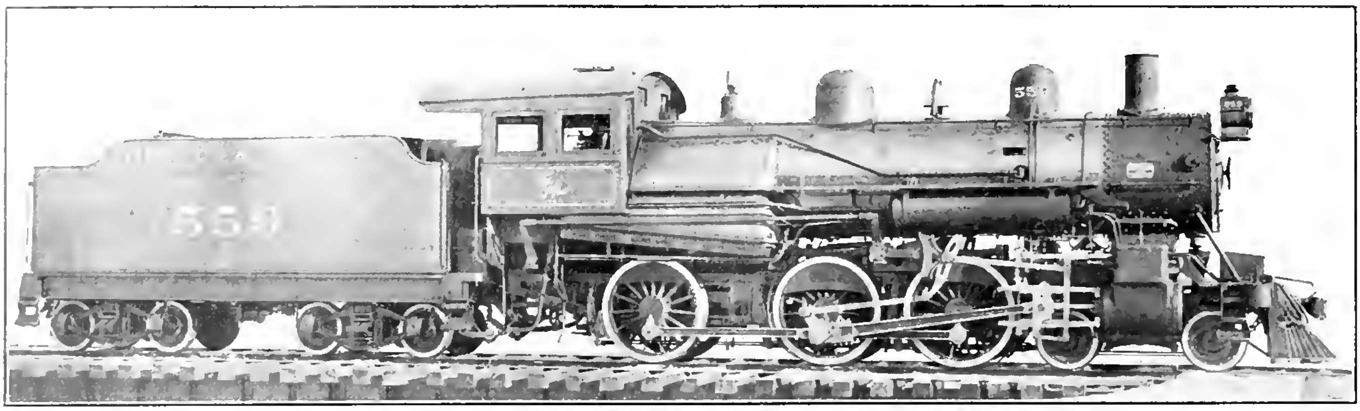
The accompanying diagram considers the fuel consumption of a group of 20 cross compound, ten-wheel, freight locomotives on the Canadian Pacific Railway, showing how it is affected by the length of time the engines have been out of the shop. The ordinates indicate the number of months the engines have been out of the repair shop. The engines were, of course, turned out of the shop at different times during the year, and to gain a fair comparison and eliminate the effect of weather and other varying conditions the fuel consumption of each engine has been compared each month with the average fuel consumption of the engines in the group. These percentages have been plotted, as shown, the larger dots indicating the average or mean for all the engines. The X marks indicate that the engines have received what is known as No. 2 repairs, or a light overhauling. Where two or more engines have the same percentage for the same month out of the shop, one is placed on the ordinate, the second and third immediately to the right or left of the ordinate, and the fourth or fifth, if there be that many, just below or just above the first one.

It will be seen that the fuel consumption for the first month out of the shop is high. It drops the second month, and in general advances from 96 or 97 per cent. the second month, to above



105 per cent. at the end of the fifteenth month out of the shop. The dots which are connected by the dot and dash lines indicate the comparative performance of engine 1000, a ten-wheel, cross compound, fitted with a Schmidt superheater. This engine ran for a period of 18 months between shoppings, but for some reason the comparative fuel consumption was very irregular between the eighth and twelfth months. The supplementary diagram for this engine, indicated by the X marks, connected by the dotted lines, was for a period immediately preceding that when the engine previously received general repairs, although at the tenth month, when this part of the diagram commences, it had received a light overhauling. We are indebted to Mr. H. H. Vaughan, assistant to the vice-president, for this information.

New Station at Washington, D. C.—The new passenger station at Washington, D. C., built jointly by the Baltimore & Ohio Railroad and the Pennsylvania Railroad, was opened on October 27. This is one of the finest, if not the finest, in the United States, and is 632 ft. long, 210 ft. wide and 120 ft. high in the main waiting room. The train shed contains 33 tracks.



CLASS D-3-B LOCOMOTIVE, WITH CAB BACK OF FIREBOX—DELAWARE & HUDSON CO.

TEN-WHEEL LOCOMOTIVE FOR GENERAL SERVICE.

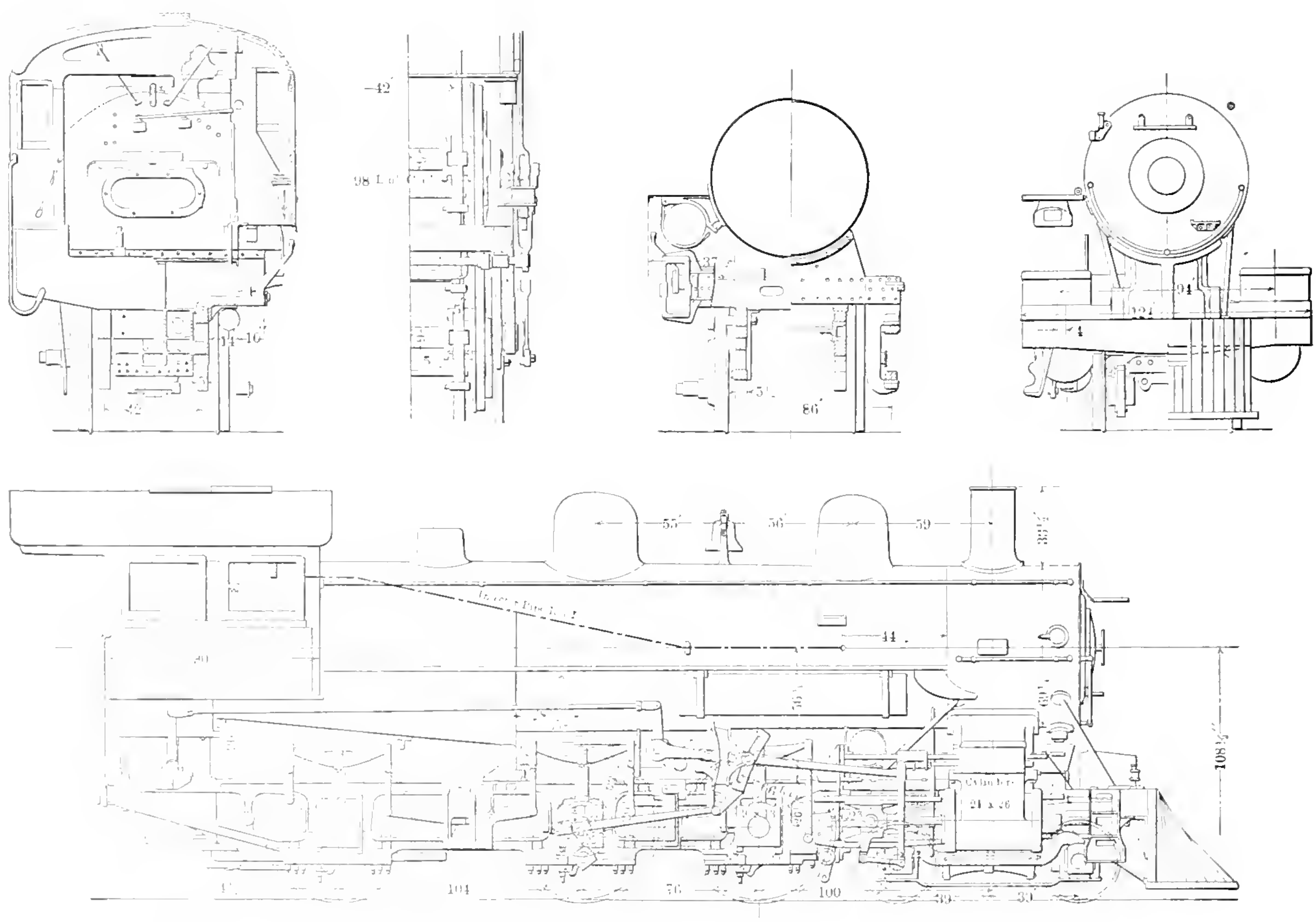
DELAWARE & HUDSON COMPANY.

The motive power of the Delaware & Hudson Company consists very largely of locomotives of the consolidation type, among which are the largest and heaviest locomotives of this type in the world. These engines, of course, handle all of the heavy slow speed trains, which form a very large part of the traffic. The lighter passenger trains are handled altogether by the 4-4-0, or American type, of which there are 77 in service. The remainder of the locomotives are divided between the 2-6-0 type, all of which were built before 1900, the 4-6-0 type and the switching types. The first two of these classes, the former of which has now been abandoned in new construction in favor of the latter, are used for the lighter freight and heavy passenger service.

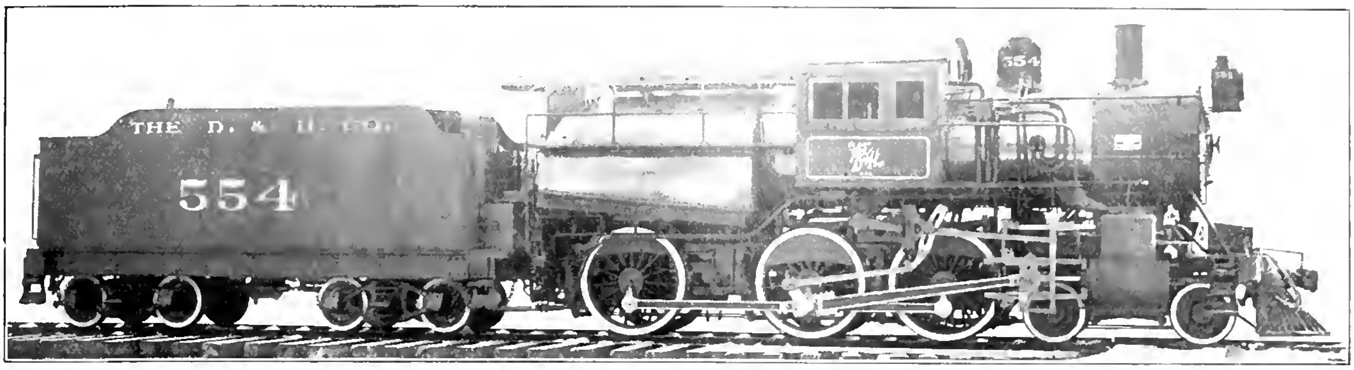
The ten-wheel, or 4-6-0, type, which is known in the road classification as Class D-3, was introduced on this road in 1903, by the delivery of an order of four locomotives from the American Locomotive Company. These engines had 21 x 26 in. cylinders, 72 in. drivers and a total weight of 175,000 lbs. This number was further increased by five locomotives of the same design

Road	D. L. & W.	D. & H.	C. & N. W.	C. P. R.
Total weight, lbs	201,000	189,000	179,500	190,000
Weight on drivers, lbs	154,000	143,000	135,500	141,000
Wgt driv ÷ total wgt., %	76.5	75.7	75.7	74.2
Tractive effort, lbs	35 100	30,900	30,900	33,300
Diameter drivers, in	69	63	63	63
Cylinders, in	$21\frac{1}{2}$ × 26	21 × 26	21 × 26	21 × 28
Steam pressure, lbs	215	200	200	200
Total heating surface, sq. ft	3,378	2,582	2959.2	2,413
Grate area, sq. ft	94.8	84.9	46.27	49.5
Tractive effort ÷ heating surf	10.4	12.	10.4	13.8
Total weight ÷ heating surface	59.8	73.	60.5	78.5
B D ratio	717.	750.	655.	870.
Heating surface ÷ cyl. vol	311.	250.	287.	215.
Reference in AMER. ENG	1905 p. 407	....	1907 p. 247	1906 p. 165

built in the shops of the company. These were followed in the next year by the class D-3-A, which have 21 x 26 in. cylinders, 69 in. drivers and weigh 174,000 lbs. total. There are four engines in that class. In 1905 and 1906 the first of the class D-3-B,



ELEVATIONS AND SECTIONS OF TEN-WHEEL LOCOMOTIVE WITH CAB BACK OF WOOTEN FIREBOX—D. & H. CO.



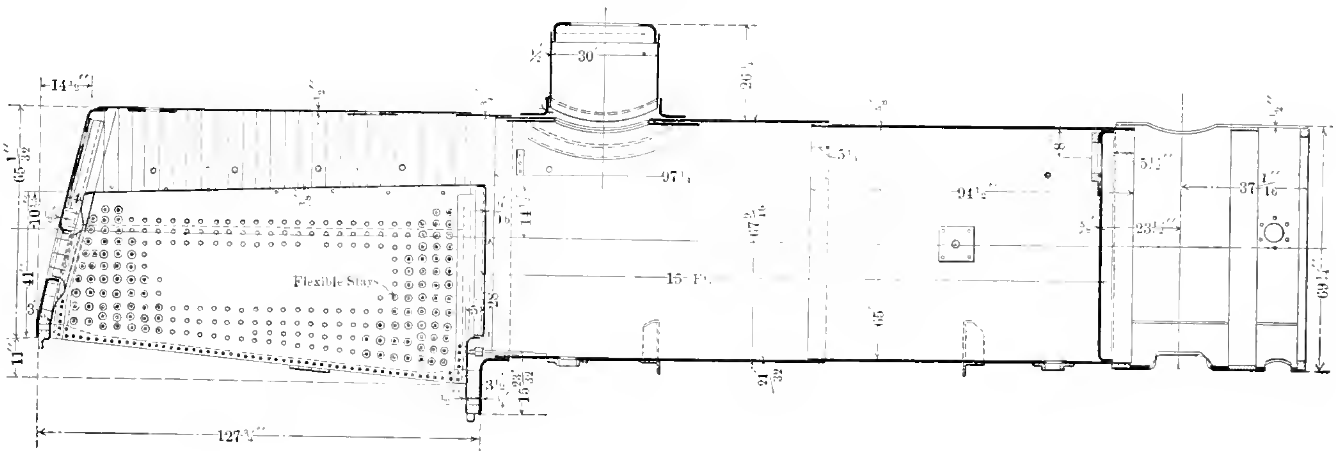
CLASS D-3-B LOCOMOTIVE WITH CAB AHEAD OF FIREBOX—DELAWARE & HUDSON CO.

which have 21 x 26 in. cylinders, 63 in. drivers, and weigh 173,000 lbs., were built at the company's shops, there being 10 in that order.

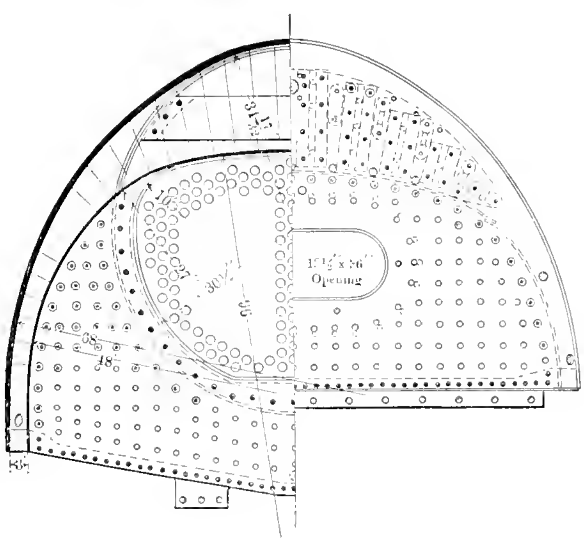
This number has recently been increased by the delivery of fifteen from the American Locomotive Company, which differ from those built at the Company's shops by having the Walschaert instead of the Stephenson valve gear and in a few other details, which brings their weight up to 186,500 lbs. Of this order of fifteen, two were built with the cab located at the rear instead of in front of the fire box, as has usually been the case with the Wooten type of boiler. This change has increased the total weight to 189,000 lbs. and the weight on drivers from 134,000 to 143,000 lbs.

The change in the location of the cab on two of these engines has been made for the purpose of keeping the engineer and firemen together, which of course is impossible with the cab ahead of the fire box. This has proved to be an advantage and the same alteration is being made in an order of 30 consolidations now being built.

The accompanying table permits the comparing of these locomotives with a number of other recent ten-wheel designs, and in studying this table it should be remembered that the Delaware, Lackawanna & Western and the Delaware & Hudson locomotives burn anthracite coal while the other two use bituminous fuel, and also that the Canadian Pacific locomotive is equipped with the Vaughan-Horsey superheater, both of which differences affect the ratios concerned with the heating surfaces.



SECTIONS OF BOILER—DELAWARE & HUDSON TEN-WHEEL LOCOMOTIVE.

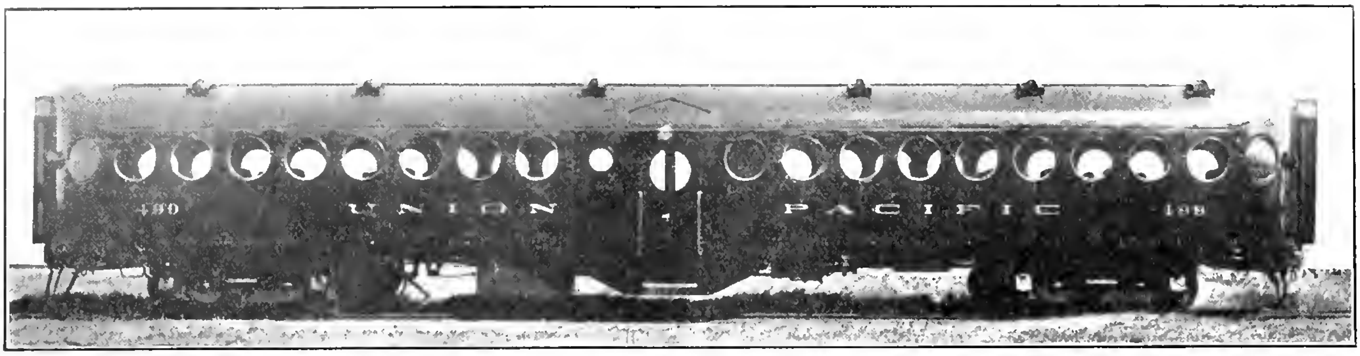


The illustrations show the construction of the boiler and machinery. It will be noted that the I-section cast steel frame, which is standard on the Delaware & Hudson, is used in this case. In other respects, however, there is nothing unusual in the design. It was of course necessary to extend the reach rod outside of the fire box, which places it very close to the clearance limits. In the design of the boiler a liberal use of flexible stays in the breakage zones and the O'Connor fire door flange will be noticed.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Anth. Coal
Tractive effort	30,900 lbs.
Weight in working order	189,000 lbs.
Weight on drivers	143,000 lbs.
Weight on leading truck	46,000 lbs.
Weight of engine and tender in working order	331,700 lbs.
Wheel base, driving	15 ft.
Wheel base, total	26 ft. 5 in.
Wheel base, engine and tender	59 ft.
RATIOS.	
Weight on drivers ÷ tractive effort	4.63
Total weight ÷ tractive effort	6.10
Tractive effort × diam. drivers ÷ heating surface	750.00
Total heating surface ÷ grate area	30.50
Firebox heating surface ÷ total heating surface, per cent	6.90
Weight on drivers ÷ total heating surface	55.00
Total weight ÷ total heating surface	73.00
Volume both cylinders, cu. ft	10.40
Total heating surface ÷ vol. cylinders	250.00
Grate area ÷ vol. cylinders	8.15
CYLINDERS.	
Kind	Simple
Diameter and stroke	21 x 26 in.

VALVES.	
Kind	Bal. Slide
Greatest travel	5½ in.
Outside lap	1 1/16 in.
Inside clearance	0 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	9 × 13 in.
Driving journals, others, diameter and length	9 × 13 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6½ × 12 in.
BOILER.	
Style	Improved Wooten
Working pressure	200 lbs.
Outside diameter of first ring	66¾ in.
Firebox, length and width	119⅞ × 102 in.
Firebox plates, thickness	⅜ and 9/16 in.
Firebox, water space at mudring	3 and 3½ in.
Tubes, number and outside diameter	308—2 in.
Tubes, length	15 ft.
Heating surface, tubes	2403.1 sq. ft.
Heating surface, firebox	178.9 sq. ft.
Heating surface, total	2582 sq. ft
Grate area	84.91 sq. ft.
Smokestack, diameter	18 in.
Smokestack, height above rail	14 ft. 8⅝ in.
TENDER.	
Wheels, diameter	33 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	6800 gals.
Coal capacity	13½ tons



ALL-STEEL PASSENGER COACH WITH CENTER DOORS—UNION PACIFIC RAILROAD.

ALL STEEL PASSENGER COACH.

UNION PACIFIC RAILROAD.

The most recent introduction of steel into the construction of railway rolling stock by the Union Pacific Railroad has been made in the building of an all-steel, fire-proof passenger coach, which has recently been turned out of the Omaha shops and placed in service between Omaha and North Platte.

This coach bears very little semblance to the ordinary passenger coach, and has been constructed on entirely new lines. The upper deck and sashes have been replaced by a semi-circular roof, similar to that of Union Pacific gasolene motor cars. A reduction of twenty-four inches in the distance from rail to roof is thus accomplished. The ends of the coach are also made circular for the purpose of reducing the wind resistance and the rectangular sash and gothic window frames are displaced by round metal sash 24 in. in diameter, which form absolute dust and water-proof windows.

The most noticeable departure from common practice in wooden car construction is the absence of steps and vestibules, the steel coach being equipped with two side door entrances in the center. The car also has a door at each end forming a passage-way to other cars.

A remarkable feature of this car is the thickness of the walls, which are only 2 in. from outside sheathing to finished surface of interior wall, a reduction of 3½ in. over the present wooden, or any fire-proof coach ever constructed. This affords an additional clearance of 7 in. in the aisles and adds materially to the comfort of passengers.

The underframe of the car consists of two 12 in. I-beams set at 16 in. centers, which act as center sills, and 6 x 3½ in. angle iron side sills. These longitudinal sills are continuous and are framed into large steel castings measuring 11 x 9 ft., which include the double body bolster, end sills and end bracing in one piece. The center sills are inserted only to carry the pulling and buffing stresses and do not carry any of the load of the car or its lading.

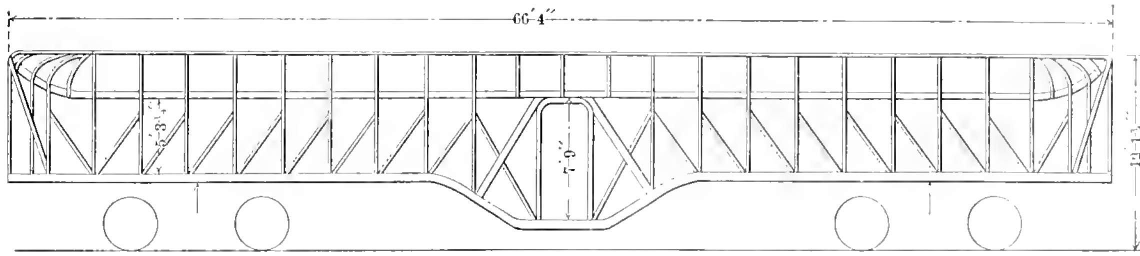
The side posts and carlines are in one continuous piece of 3 in. channel iron, which is bent into the form of a letter U and extends continuously from side sill to side plate, thence over the roof and down to the side sill on the opposite side. These posts are set with the web of the channel parallel with the side sills.

The side plate of 4 in. channel iron is attached to the side posts at the eaves and acts as the upper chord of the side girder the web of which is formed by the ⅛ in. steel side sheathing and the lower chord by the side sill. The posts act as stiffeners and a number of diagonal braces placed below the windows are inserted for further stiffness. All of this construction is thoroughly riveted together. Holes 25 in. in diameter are cut out of the sheathing and in this are inserted the aluminum frames

INTERIOR OF UNION PACIFIC STEEL PASSENGER COACH.

for the circular windows. The end framing is similar to that used on the sides, being formed of the same size and shaped parts, which are framed and riveted to suit their respective locations.

A 1/16 in. steel plate is riveted over the underframe and upon this is a layer of ¾ in. hair felt. Above this the flooring of fireproof composition in pressed sheets ½ in. thick is laid on nailing strips embedded in the felt. Stove bolts, with heads flush with

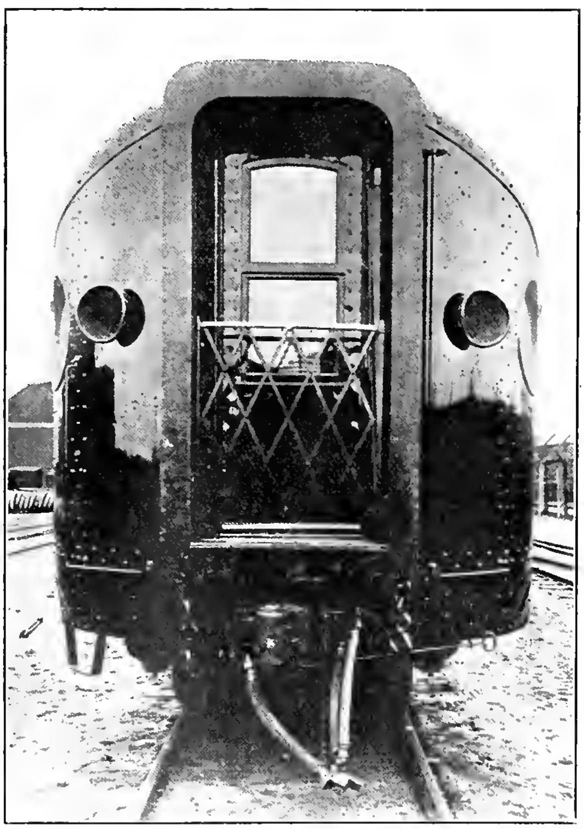


OUTLINE DIAGRAM OF FRAMING—UNION PACIFIC STEEL COACH.

the floor, fasten the floor construction together. The only wood used in the construction of this car is in the shape of filling blocks, there being altogether about 200 lbs.

The circular windows are equipped with an aluminum sash in which is fitted a 24 in. glass. This sash is hinged at the top and a special window catch is provided for holding them in a horizontal position when swung up. A half round rubber gasket is fitted between the frame and the sash and forms an absolutely weather and dust proof joint.

Special attention has been given to the ventilation of this car and Cottier suction ventilators of an improved design are placed at intervals on the roof on each side of the center line of the car. These draw out the bad air. Fresh air is admitted through the circular openings seen in the end view of the car, which are located about 8 ft. from the rail and are 12 in. in diameter. They are covered with a fine brass net and connect to a sheet iron conduit placed beneath the floor, and containing two sets of removable dust collecting screens. After passing the screens the purified air is admitted to the inside of the car, along the sides,



END VIEW OF UNION PACIFIC STEEL COACH.

through a galvanized sheet iron duct having perforations opposite each seat. The steam heating pipes are placed along the outside of the air duct and heat the air before it is admitted to the car. Dampers are provided for controlling the amount of fresh air admitted.

The car is lighted by electricity, the current being obtained from a generator belted from the axle. An 8 candle power lamp, with frosted globe, is fitted in the side of the car, opposite each seat, being slightly above a seated passenger's head.

The weight, general dimensions, etc., are shown in the following table:

Actual weight	89,300 lbs.
Length over diaphragms	68 ft.
Height, rail to roof	12 ft. 1¼ in.
Height, floor to ceiling	7 ft. 8¼ in.
Width inside at wainscot	9 ft. 5⅝ in.
Width of aisle between seats	3 ft. 5⅝ in.
Width of car over side sills	9 ft. 5⅝ in.
Roof sheets, galvanized iron	1/16 in.
Truck	4-wheel cast steel
Seating capacity of coach	78

ENGLISH RAILWAY DYNAMOMETER CAR.

The North Eastern Railway of England has recently completed a dynamometer car designed by Mr. Wilson Worsdell, general mechanical engineer, which contains a number of very interesting features.

The draw bar connects directly to a large flat spring located in about the center of the underframe, which consists of 30 selected steel plates, each separated by rollers so as to eliminate the leaf friction. This spring is 7 ft. 6 in. long, between the centers of the roller stops at the ends, and is enclosed in a dust proof box forming part of the steel underframe of the car. The center band of the spring, to which the draw bar is connected, is supported on a carriage having four wheels resting on polished steel plates. The same band, which is practically part of the draw bar extension, carries a bracket projecting up through the floor of the car and carrying at its upper end a stylographic pen for giving the record of the draw bar pull.

The design and construction of this spring was given the most careful attention and the plates composing it are of the highest quality. Each was separately tested before being put into place and after assembling the spring was very carefully calibrated and found to give a uniform rate of deflection.

The paper driving mechanism consists of a large wheel 3 ft. 9.836 in. in diameter fitted with a very hard flat steel tire and accurately ground to size, which rolls on the rail and can be raised or lowered at will. It is located just inside of one of the trucks. A set of gears is provided for giving different speeds to the paper driving rolls.

The recording table has eight electro-magnetic pens, which can be coupled up through a terminal board as desired and give almost any desired record. A mechanical integrator, consisting of a horizontal, flat, steel plate rotated by gearing from the paper driving mechanism, over which is a frame supporting a small wheel set on edge and connected with the draw bar so as to move across the flat plate at a distance from the center proportional to the pull of the draw bar, is provided. The speed of revolution of the small wheel is a direct measure of the work done and an electrical contact arrangement permits this record to be made upon the roll of paper.

Other instruments in the car show either on dials, or by means of the electro-magnet pens, a permanent record of, the speed, steam chest and boiler pressure, velocity and direction of the wind, time of taking indicator cards, location of curves and permanent objects along the line, brake cylinder, auxiliary reservoir or train pipe pressure, revolutions of the driving wheels, position of the reversing gear, etc.

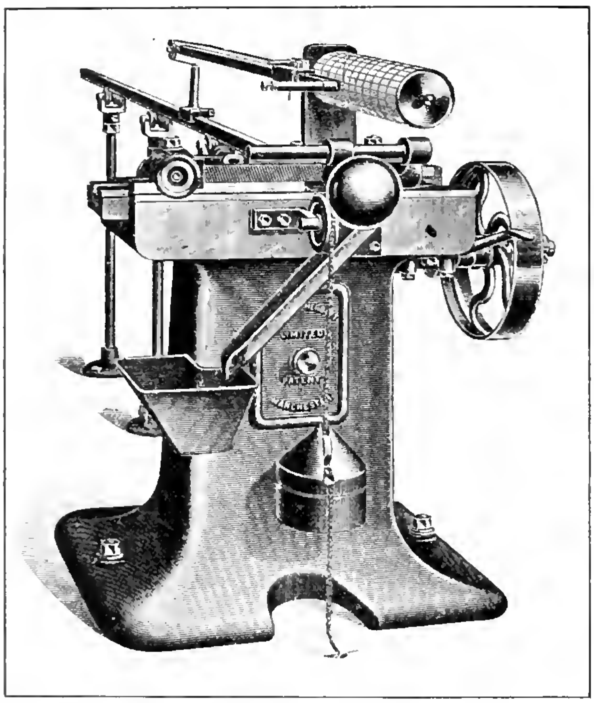
The draw bar connection is arranged with the usual spring draft gear and provision is made for inserting a key so that the dynamometer can be cut out of service if desired. The center of the body of the car is constructed with a shallow bay window on both sides which permits a view to be obtained almost directly ahead, without the opening of the windows.

An illustrated description of this car will be found in the October 4 issue of the *Engineer* of London.

TESTING FILES.

It is practically impossible to test files accurately by hand. A good file may take 100,000 strokes with little loss of sharpness, while one of poor steel, but well cut, may cut as fast when new, but fail after a few thousand strokes. To ascertain its quality accurately it must be completely worn out in the test. A file testing and indicating machine was invented in England in 1905 and sample files from the leading English and American makers were tested. Some of these were worn out after filing away less than a cubic inch of iron, cutting at a rate of a cubic inch per 10,000 strokes; the best file removed 121 cubic inches of metal, cutting at a rate of 5 cubic inches per 10,000 strokes.

The publication of the results of these tests created a sensation. A public file testing department was established in England and a number of the file makers installed testing machines and experimented with their product to determine the most efficient form of file tooth and the most suitable quality of steel to be used. Files are now made which cut at the rate of 8 cubic inches per 10,000 strokes, and as much as 55 cubic inches have been removed by one side of a single file. The testing machine makes it possible to trace the effect of slight modifications in the manufacturing processes. It also permits the user to order files on a basis of quality and check the files supplied.

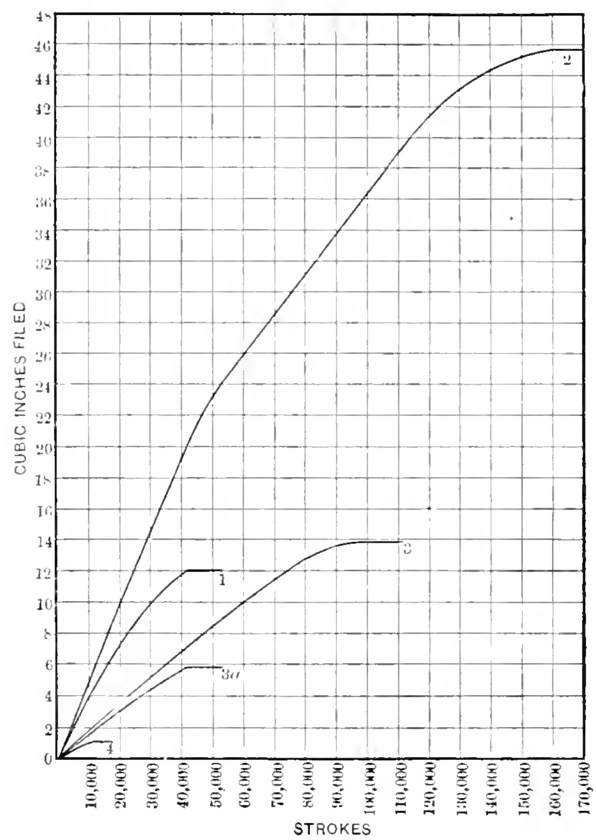


HERBERT FILE TESTING MACHINE.

The machine, shown in the illustration, automatically tests files of any size from 4 to 16 inches, drawing a diagram which indicates exactly the work done (cubic inches filed away), the sharpness as indicated by the rate of cutting and the durability as indicated by the number of strokes taken before the file ceases to cut. The file is reciprocated against the end of a test bar, which is supported on rollers and is forced lengthwise against the file by means of a weight and chain, giving a constant pressure. The bar is withdrawn during the back stroke. A diagram is made on a sheet of section paper wrapped around a drum, after the manner of a steam engine indicator. The drum is geared to revolve slightly with each stroke of the file, and a pencil connected with the test bar is moved across the paper as the bar is filed away. The result is a diagram showing what the [illegible] every minute during the test.

The diagrams illustrated show the results of tests of four bastard files made by well-known makers and are typical of the large number of tests that have been made. The vertical distances represent the number of inches filed from a standard test bar of annealed cast iron planed to a section 1 in. square. The ordinates indicate the number of strokes of the file. In each case the files were tested until they ceased to cut, as shown by the diagram. The rate of cutting at any period is shown by the slope of the corresponding portion of the curve. Curve 1 is from a file of good average quality as usually supplied by the best makers. It cuts quickly, but soon wears out, indicating sharp teeth but poor steel. Curve 2 is from one of the new files of modern high class steel with correctly formed teeth. These have been introduced since the advent of the file testing machine. Curves 3 and 3a are from the two sides of another file. Durability was fairly good, but rate of cutting slow, showing good steel but bad teeth. Curve 4 is from a bad file. It will be seen that file No. 2 cut five times as fast when new, lasted 16 times as long, and did 46 times as much work as file No. 4.

Special importance attaches to the rate of cutting because of its bearing on the wages cost of a given quantity of work. The expenditure in files, wages, and establishment charges, incurred in filing away 100 cubic inches of metal with a given make of file



TYPICAL DIAGRAMS OF TESTS OF FILES.

is the best test of its efficiency and is given in shillings by the following formula:

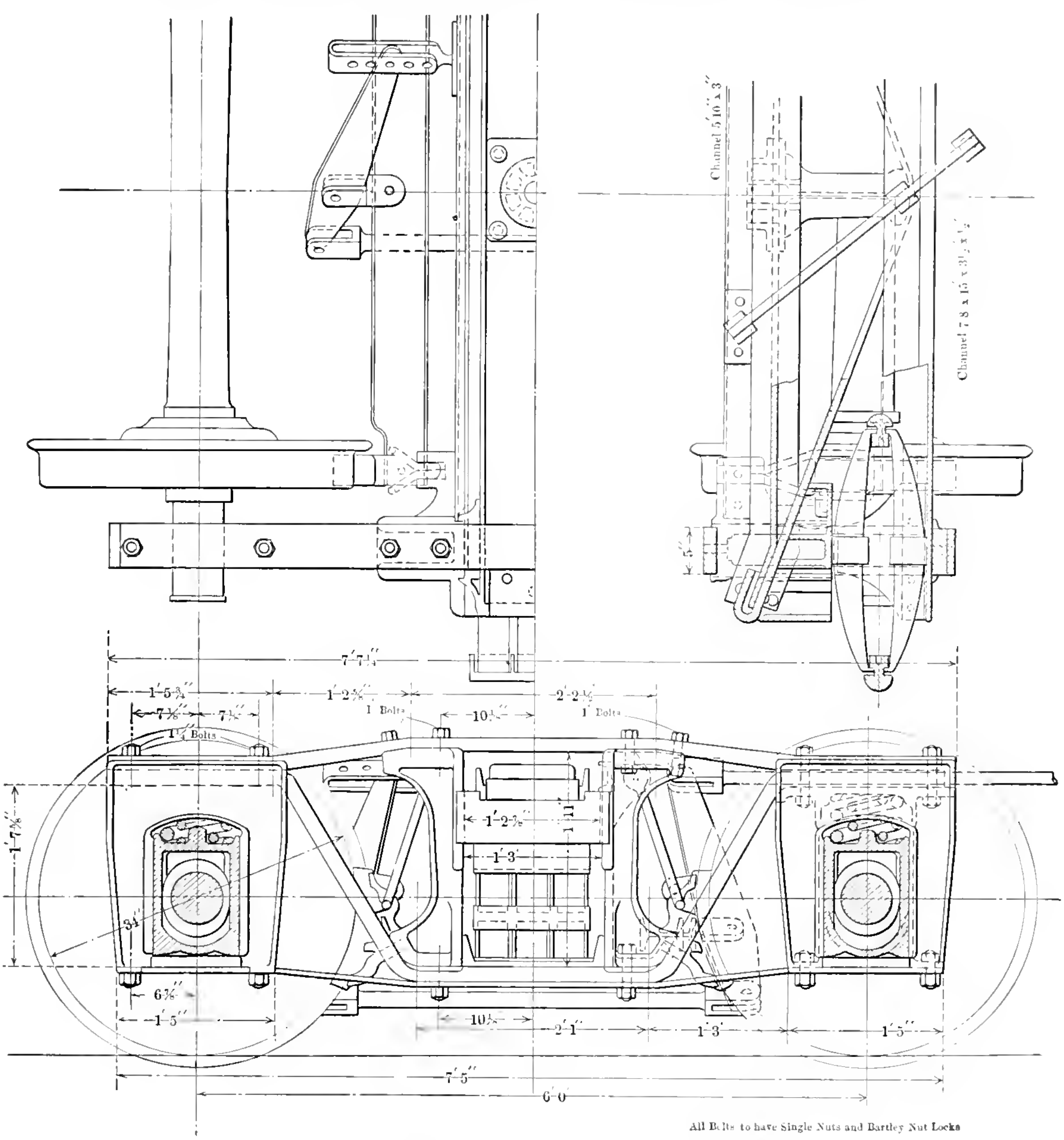
$$C = \frac{L\,(100 - D)}{I} + \frac{350}{R} \text{ in which}$$

L = list price of a file.
D = discount off list.
I = total inches filed away by both sides of file (from diagram).
R = mean rate of cutting (inches per 10,000 strokes, from diagram). The formula assumes that the workman is rated at one shilling per hour (wages and establishment charges).

If file No. 2 was sold at 40 per cent. and file No. 3 at 60 per cent. off Sheffield list, the total cost of filing away 100 cubic inches of iron would be: with file No. 2, 4 pounds 16 shillings ($23.32); with file No. 3, 13 pounds ($63.18).

Files to be tested should be selected from the lot and should not be "samples." Both sides should be tested as there is often a considerable difference in two sides of the same file.

We are indebted for this information to Edward G. Herbert, Ltd., engineers and machine tool makers, Rosamond street East, Manchester, England, who manufacture the testing machines and make a specialty of testing files for makers and users.



NEW TYPE OF ARCH BAR TENDER TRUCK—CANADIAN PACIFIC RY.

TENDER TRUCK.

CANADIAN PACIFIC RAILWAY.

The Canadian Pacific Railway is equipping the Pacific type locomotives, which it is building, with a new type of arch bar tender truck. The trucks formerly used were of the ordinary arch bar type and considerable difficulty was experienced due to the breaking of the arch bars, especially the lower ones, during the severe winter weather. Column bolts were also broken and the threads sheared off at the ends due to hard track conditions. To overcome this, and at the same time make an easier riding truck, the design was changed to permit the use of coil springs over the journal boxes. The cast steel column castings, as shown in the illustration, are carefully designed to support or reinforce the arch bars at the bended portions where they usually fail. Short column and journal bolts are used in place of long ones to insure the parts being drawn together more securely and to facilitate repairs. A lug or projection is cast on the column castings from which the brakes are hung. Simplex bolsters are used.

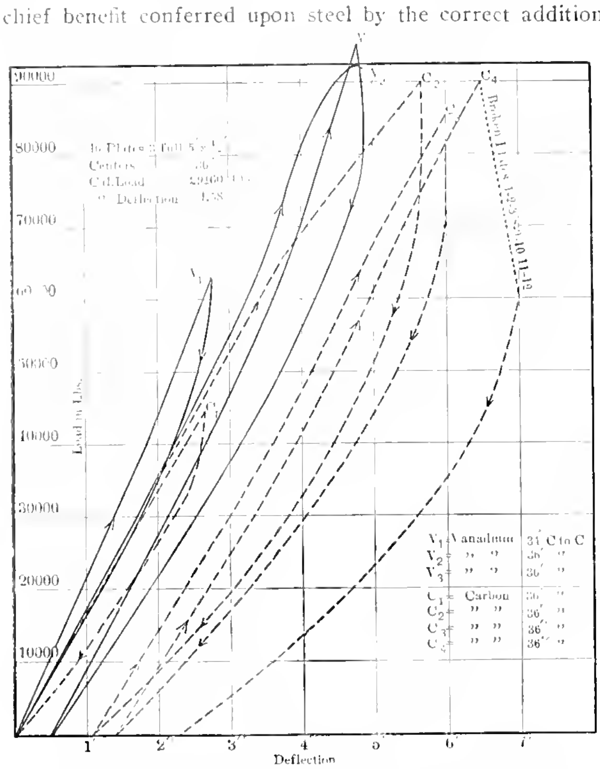
TIME NOT RIPE FOR GENERAL ELECTRIFICATION.—Nor does the writer believe that the time is ripe for the electrification of steam roads at large; indeed, the electrical enthusiasts would be hard put to it if called upon to show reason for the electrification of many branch steam lines carrying a small tonnage at infrequent intervals. There are, however, certain divisions of our steam railways which, either on account of their broken profile or heavy traffic, offer an opportunity to introduce a superior type of motive power which will effect such economies in operation as to provide adequate return on the investment required for the electrification. There are still other divisions where a much desired increase in the track-tonnage capacity can only be effected by double tracking so long as the steam locomotivè is adhered to as the type of motive power used. Double tracking a mountain-grade division is often a matter of enormous expense, and electrification of the single track may relieve the present traffic congestion at a moderate cost.—*Mr. A. H. Armstrong before the Amer. Inst. Elect. Engineers.*

CLUB HOUSES ON THE SOUTHERN PACIFIC RAILROAD.—The Southern Pacific Railroad is building a number of club houses at division points along its lines in Nevada, California, Arizona, New Mexico and Texas. These clubs are for the use of employees of all classes and include the usual club facilities and in addition have a number of bedrooms arranged so that they may be darkened during the day. No dues are demanded from members and a very small charge is made for the use of the dormitories and bath rooms. Outside of this, which hardly covers the maintenance charges of these quarters, the railroad company pays all the bills. These clubs are proving to be very popular and are said to be an excellent thing from all points of view.

VANADIUM STEEL.*

By Mr. J. Kent Smith.†

When some years ago the statement was recorded that the addition of vanadium to steel strengthened the latter, the asseveration did not appeal much to practical man for many reasons, two of which were: that vanidium was looked upon as an exceedingly rare metal which was quite inaccessible for use in industrial operations, and that the extraordinary properties which vanadium conferred on steel in addition to strengthening it were not even hinted at; in fact, it is only in very recent times that the chief benefit conferred upon steel by the correct addition of



Comparative Tests on Vanaoium and Carbon Steel Springs. Tested by the American Locomotive Company.

The Vanadium spring was tested:
1. To 62,700 lbs. with 34″ centers.
2. To 92,000 " " 36″ "
3. To 94,000 " " 36″ "

On second test elastic limit was reached at 85,000 lbs. or 234,500 lbs. fibre stress with permanent set of .48″.
The third test was repeated three times without the least variation from recorded heights.
Type "D." Vanadium Spring Steel.

The Carbon spring was tested:
1. To 44,000 lbs. with 36″ centers.
2. To 89,280 " " 36″ "
3. To 84,520 " " 36″ "
4. To 89,280 " " 36″ "

On second test, elastic limit was reached at 65,000 lbs. or 180,000 lbs. fibre stress with permanent set of 1.12″.
On third test, it took an additional set of .26″, and on fourth test, plates 1, 2, 3, 8, 9, 10, 11, 12 failed at the center.

Static test on piece cut from leaf of spring:

Elastic limit	227,100
Ultimate strength	237,500
Ratio	96%
Elongation, 2″	10%
Contraction of area	35%

FIG. I.

vanadium has been recognized at all, that is, that of endowing it with extreme vitality, or phenomenally high resistance to the fatigue produced by repeated stresses and strains which in the end cause its fracture, although they may singly be below the elastic limit of the metal. Even now this fact has not received the full amount of recognition which it deserves.

Recent discoveries have caused vanadium to pass entirely from the domain of the rare metals to the position of a metal which is readily obtainable in any quantities and at a price which, considering the small proportion necessary to be used, does not put any obstacle in the way of its employment in steels of even a moderately high grade.

An immense deposit of vanadium ore, of a grade which was not hitherto suspected to exist, or even to be capable of existence, has been developed, and is now being worked. Vanadium is commonly alluded to as a rare metal, but this denomination is correct in a limited sense only. Scientifically the description is entirely inaccurate, as vanadium is one of the most widely distributed of the elements known to us; but in its general forms of distribution it occurs only in such minute quantities as to render any idea of its commercial extraction from such sources utterly impracticable. It is, however, exceedingly rare to find concentrated sources of vanadium in any quantity, so rare, in fact, that the deposit previously spoken of may be reckoned as unique.

It is a silvery white, readily oxidized metal of a very high fusing point. Its alloy with iron, however, in the proportion of approximately two parts of iron to one of vanadium possesses a melting point much below that of steel, and it is in this form that the metal is marketed for the use of the steel manufacturer. No difficulties in its employment are found, provided that reasonable precautions are taken in its addition.

It will be necessary in the first place for me to allude briefly and generally to the micro-structure of the ordinary engineering steels, or such steels as those which are known to metallurgists as "sub-saturated." Carbon is a necessary constituent of all steels, but this carbon is not held in mere solution in the steel nor is it disseminated in the steel in an elementary condition. The ground work of the steel may be said to consist of a carbonless iron of a greater or less degree of purity, and the properties of different forms of this carbonless iron, and their structure both from an intercrystalline and intracrystalline point of view, must first be considered both chemically and physically. Such carbonless iron is known generically as ferrite. In the steel the carbon itself is combined chemically with another proportion of iron forming the chemical compound carbide of iron, a molecule of which contains three atoms of iron and one atom of carbon. This chemical compound alloys itself with more carbonless iron, each molecule taking to itself twenty-one more atoms of iron to form the eutectoid known as pearlite. The particles of this pearlite alloy are distributed in pieces of greater or less size through the main ground work of ferrite, their size, distribution, etc., varying according to the last heat put upon the steel under "work," the rate of cooling, and so forth. From the foregoing it will be seen that, having careful reference to atomic weights, etc., a steel containing .89 per cent. of carbon would completely consist of pearlite, there being no excess of carbonless iron; such a steel would be called "saturated." If the carbon percentage exceeds this amount there would be an excessive quantity of carbide of iron over that required to form pearlite, and this steel would be called "supersaturated." But only the subsaturated steels interest us at present from an engineering point of view.

It has already been said that vanadium is a readily oxidizable element. Amongst the metals it stands very high on the list with regard to its avidity for oxygen; so great is this avidity that under suitable temperature conditions it will decompose the oxides of iron and manganese. It is within the province of the steel-maker to insure the practical absence of these oxides by normal means, but the addition of vanadium insures the complete elimination of the last traces, thereby ridding steel of one of its most dangerous poisons. As their removal is effected by conversion into a light and readily fusible oxide of vanadium which immediately passes into the slag, no danger of the "dryness" attending the use of some deoxidizing agents is encountered. But even more important is the fact that vanadium also eliminates combined nitrogen in the form of a stable nitride.

Aside from the benefits derived from the cleansing action of vanadium (which work be it noted is accomplished at the expense of the ultimate vanadium content of the steel) there are many other points to be observed. The solid solution of vanadium in ferrite causes this ferrite to become much tougher from an intracrystalline point of view, and furthermore promotes the close interlocking of these crystals. Incidentally the ferrite crystals in themselves become somewhat stronger from a purely tensile point of view.

The main practical application of this fact lies in the employment of vanadium in steel castings. It will, I think, be generally admitted that the great majority of castings fail in service through their inability to withstand the disintegrating effect of

* From a paper presented before the Railway Club of Pittsburg, Sept. 27, 1907.

† Chief metallurgist, American Vanadium Company.

repeated stresses rather than to any original want of static strength and ductility. This lack of endurance cannot possibly be gauged by any static test.

Further, vanadium ferrite offers greater resistance to the passage through it of carbides than does plain ferrite, thus rendering the vanadium steels particularly suited to the great improvements conferred by judicious tempering, while it furthermore renders the tempering limitations wider. These two points assume great practical importance.

Another portion of the vanadium enormously strengthens the pearlite alloy, raising its elastic limit especially, and in addition promotes the cohesion of this alloy with ferrite. From these facts the explanation is readily seen as to why the strengthening effect of vanadium increases rapidly as the proportion of elements other than iron (such as carbon, nickel, chromium, manganese, etc.) rises to the limits allowable in engineering steels, which limits are fixed by other considerations which it is needless for me to enter into.

The following table illustrates the effects of vanadium in increasing the static strength of material:

Rolled Bars Untreated.	Elastic limit. Lbs. per sq. in.	Ultimate tensile stress. Lbs. per sq. in.	Elongation on 2 in. Per cent.	Reduction of area. Per cent.
Crucible Steels 0.20% Carbon:				
Plain Carbon-manganese	35,840	60,480	35	60.0
" + 0 5 per cent. chromium	51,296	76,160	33	60.6
" + 1.0 " "	56,000	85,568	30	57.3
" + 0.1 " vanadium	63,840	77,052	31	60.0
" + 0.15 " "	68,096	81,760	26	59.0
" + 0.25 " "	76,384	88,032	24	59.0
" + 1.0 " chromium + .15 " vanadium	81,088	108,864	21	56.6
" + 1.0 " chromium + 0.25 " vanadium	90,496	135,296	18.5	46.3
Open-hearth Steels 0.3% Carbon:				
Plain carbon-manganese	39,648	72,128	34	52.6
" " + 1.0 per cent. Chromium + 0.15 " Vanadium	77,056	116,480	25	55.5
Crucible Steels 0.2% Carbon:				
+ 5% Nickel Steel	58,240	94,080	24	50.0
" " + .25% vanadium	116,700	129,700	20.5	52.4

It may be said what is now generally recognized, that it is not lack of successful resistance of steel to one steadily applied strain which causes that steel to fail in the huge majority of instances, but rather its steady deterioration under the demoralizing effect of strains which, though in themselves very much less severe, are continually repeated. A true factor of safety can only be arrived at by consideration of both the useful strength of the material (which useful strength, be it noted, is represented by the elastic limit and not by the ultimate stress required to break the metal) and its ability to withstand deterioration under repeated stresses and strains, both statically and dynamically applied. The absolute pre-eminence of vanadium steels in resisting such deterioration has been thoroughly established as the result of many thousands of dynamic tests made under all kinds of conditions.

Table No. 1 also illustrates the high combinations of static and dynamic excellence obtainable by oil-tempering the vanadium compound steels, while table No. 2 illustrates the great effect of vanadium on the improvement in strength due to oil tempering.

Table No. 3 enumerates some of the leading types of vanadium steel in general use and the applications to which these various steels are put. Type "A" and its milder variants, "B" and "C," have already been sufficiently spoken of.

The tempered type "D" steel is exceptionally suited for the manufacture of springs, as will be seen from the diagram (Fig. 1) illustrating the results of comparative tests of vanadium and carbon steel railway springs made by an independent examiner. These springs were 16-leaf locomotive springs made to a standard design. It may be said that a new "carbon steel" spring was tested, but that the vanadium steel spring tested had already been subjected to gross distortion; its great superiority, however, even under the circumstances, is amply demonstrated. Variants of this class of steel in a softer condition than that pertaining to a spring are particularly applicable to the preparation of rails, tires, solid wheels, etc., a metal of great strength, high resistance to shock, impact, repeated stresses and of a structure highly resistant to abrasion being attainable by direct means.

Time will not permit me to go with any semblance of detail into the subject of case-hardening. As the object of case-hardening is to obtain an article which, although it has an exceedingly hard surface, at the same time shall have a tough resistant core, it naturally is inadmissible to case-harden any steel which in itself "takes a temper" as the result of quenching. The great increase in strength due to quenching mild vanadium steel is il-

TABLE NO. 1.

Test.	Carbon "Axle" Steel.	Nickel "Axle" Steel.	Vanadium "Axle" Steel, Type A No. 1.	Vanadium Crank Shaft Steel, Type A No. 2.	Vanadium Gear Steel, Continual Mesh, Type A No. 3.
Yield point, lbs. per sq. in	41,330	49,270	63,570	110,100	224,000
Ultimate stress, tensile strength in lbs. per sq. in	65,840	87,360	96,080	127,800	232,750
Ratio	62%	56%	66%	87%	96%
Elongation on 2 in.	42%	34%	33%	20%	11%
Contraction of area	61%	58%	61%	58%	39%
Torsional twists	2.6	3.2	4.2	2.5	1.8
Alternating bends	10	12	18	10	6
Pendulum impact, foot pounds	12.3	14	16.5	12	6
Alternating impact, No. of stresses	960	800	2,700	1,850	800
Failing weight on notched bar, number of blows	25	35	69	76	......
Rotary vibrations, number of revolutions	6,200	10,000	67,500	......	......

TABLE NO. 2.

Crucible Steel.	Elastic Limit Lbs. Per Sq. In.	Ult. Tens. Strength Lbs. Per Sq. In.	Elongation % on 2 inch.	Reduction Area %
*Carbon Steel as Rolled	61,100	82,700	24	49.7
" " Oil Tempered	71,460	91,800	17	52.3
Chrome Vanadium Steel as Rolled	90,500	135,300	18.5	46.3
" " " Oil Temp'd.	141,000	147,000	17	57.0
Nickel Vanadium Steel as Rolled	116,700	129,700	20.5	52.4
" " " Oil Tempered	179,900	185,300	14.5	50.5

* N. B.—The Carbon Steel was made in the crucible from a Swedish "base" and therefore shows higher results than would be expected in ordinary open hearth practice.

TABLE NO. 3.

Type.	Composition.	Applications.	Heat Treatment.
A 1	Carbon .25—.30% Manganese .4—.5 % Chromium. 1% Vanadium. .16—.18%	Light axles, connecting rods, side and main rods, driving axles, piston rods.	Anneal at 800° C. for one to two hours, cool in air or ashes.
A 2	Carbon .25—.30% Manganese .4—.5 % Chromium. 1% Vanadium. .16—.18%	Crank sbafts, transmission parts, crank pins.	Quench from 900° C. in lard or fish oil and anneal at 550° C. for ½ to 2 hours in air.
A 3	Carbon .25—.30% Manganese .4—.5 % Chromium. 1% Vanadium. .16—.18%	Gears in constant mesh.	Quench from 950° C. in lard oil and let down at 360° C. for ¼ to ½ hours preferably in lead bath. Cool in air.
B	Carbon .2 % Manganese .3—.4 % Chromium .5 % Vanadium .12%	Axle work, hammer rods and where torsion is of great moment, bolt steel.	Normal.
C	Carbon .2 % Manganese .4 % Chromium .8 % Vanadium .16%	Intermediate steel, useful for car axles, holding bolts, etc.	Normal.
D 1	Carbon .45—.55% Manganese .8—1.0% Chromium 1.25% Vanadium .18%	Solid wheels for railways, gun barrels, crank pins.	Anneal at 800° C. for one hour, cool slowly, taking great care not to chill or to pass from 800° to 600° too quick.
D 2	Carbon .45—.55% Manganese .8—1.0% Chromium 1.25% Vanadium .18%	Springs for automobile, carriage and locomotive work.	Quench in oil from 900° C. and draw back at 400° to 450° C. in lead bath preferred. Cool in air.
E	Carbon .12—.15% Manganese .2 % Chromium .3 % Vanadium .12%	Case hardening steel for all engine and machine parts.	Regular case hardening process.

Remarks.—All steels to be as pure as possible from sulphur and phosphorus. Sulphur may go to .035% without detriment. With phosphorus at .02% silicon may be .15% in D and .10% in A, B, C, With phosphorus at .03% silicon should not exceed .05% to .06% in A, B, C, or .1% in D.

TABLE NO. 4.

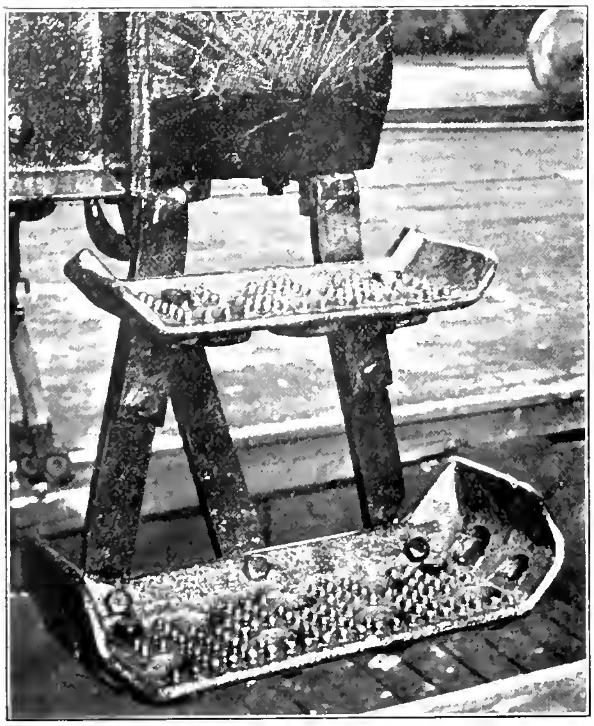
	Vanadium Low Carbon Steel as Rolled.	The Same Steel Quenched in Water from 850° C.
Elastic limit (lbs per sq. in.)	44,790	78,390
Ultimate tensile strength (lbs. per sq. in.)	55,990	100,800
Elongation on 2 in.	45%	22%
Reduction of area	69%	60%

lustrated in table No. 4 and its power of toughening carbides has been dealt with.

Taking advantage of these points, the outside carburizing and the quenching of special mild vanadium steel leads to results which are unapproachable when combinations of resistance to wear, strength, and toughness are considered.

A SENSIBLE TENDER STEP.

The Canadian Pacific Railway has recently adopted as standard the tender step, shown in the illustrations. The two-inch holes in the step allow the snow and ice to fall through, while



TENDER STEP—CANADIAN PACIFIC RAILWAY.

the small projections or lugs afford a secure foothold. The high flanges prevent the feet from slipping over the ends. Those who have occasion to climb aboard engines or tenders, especially during winter weather, or when the light is poor, will readily appreciate the good features of this design.

TO PROMOTE THE RESUMPTION OF NORMAL BUSINESS CONDITIONS.

At a meeting of the Board of Directors of The Merchants' Association of New York, Thursday, November 21st, the following resolution was unanimously adopted:

Resolved, That the Board of Directors of the Merchants' Association of New York submits the following views and recommendations concerning the present financial situation for the consideration of its members and others, hoping thereby to promote the common welfare and to accelerate the resumption of business under normal conditions, viz.:

1. The chief present difficulty is stringency caused by the hoarding of the circulating medium of the country.

2. All financial leaders and practically all banking institutions have united in urging the people to cease this hoarding and to restore the circulating medium to its customary channels and uses.

3. The banks, above all others, should set the example thus implied; some of them have done so, but many are alleged to be doing just what they condemn in others. For example, some are known to be holding cash reserves ranging from two to five times the normal ratio.

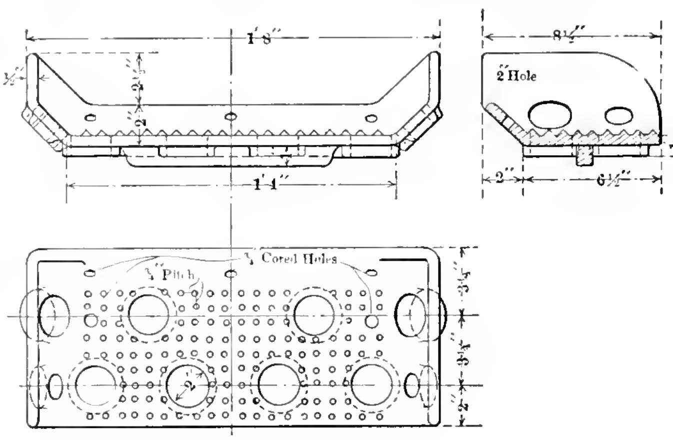
4. The purpose of a surplus or cash reserve is for use in time of need; to withhold it from such use is to defeat its true purpose, tends directly to increase the condition which it should alleviate, and is a selfish effort to protect the individual bank at the expense and to the injury of the banks collectively.

5. Checks payable "Through Clearing House only" are useful for local settlements, but do not pay non-local debts. The business of all large manufacturing and mercantile concerns is chiefly non-local, and cannot go on if local funds are everywhere tied up. Interstate exchange is essential to the conduct of interstate business, and this constitutes the greater part of our domestic exchanges. Provision for the settlement of local indebtedness is helpful, but provision for the settlement of non-local indebtedness is essential, and, therefore, still more helpful.

6. If all concerned and in all parts of the country will recognize and act upon these self-evident conditions which underlie our commercial and financial system; if each corporation, bank and individual, instead of hoarding currency, will pay it out or deposit it in bank, and, instead of deferring settlements, will pay every account as promptly as possible, then, as predicted by Secretary Cortelyou in his notable address to The Merchants' Association on the 14th inst., there will be "within twenty-four hours an almost complete resumption of business operations," and the present stringency will become a thing of the past.

7. Our crops are large, our mining, manufacturing and commercial facilities greater than ever before, our transportation facilities overtaxed to handle the business which is offered to them, our population is larger and its consuming power greater than at any previous period, and no undue accumulation of merchandise is known to exist.

8. No comparison can fairly be made between the sound basic conditions prevailing to-day and the unsound conditions which obtained in 1893. We are now firmly on a gold basis, with an overflowing National Treasury.



DETAILS OF TENDER STEP.

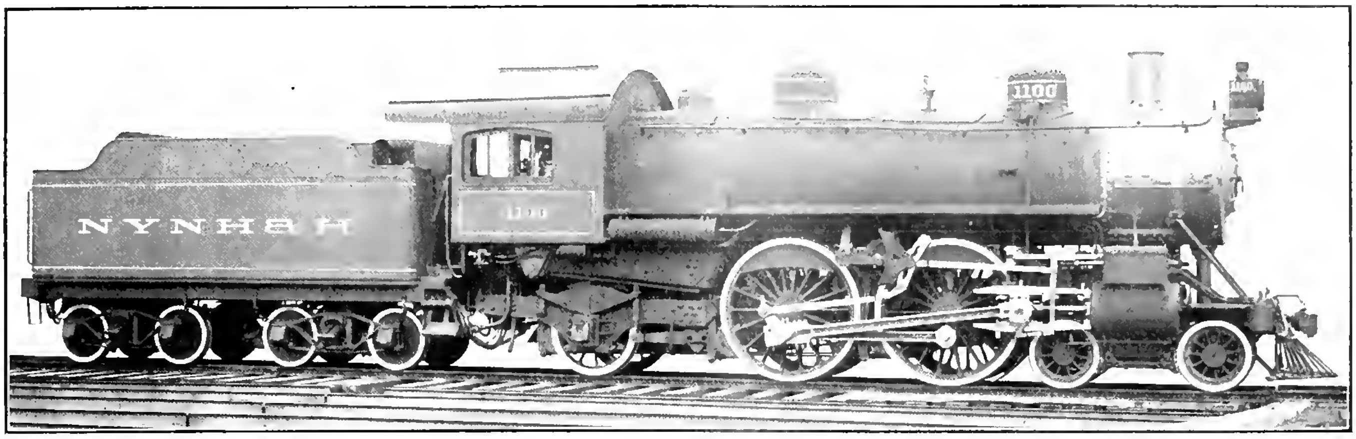
The recent trouble has been attributed to an "excess of prosperity." Wise legislation by Congress to make our currency elastic enough readily to respond to business conditions may confidently be looked for this winter. With all of these favoring conditions the onward march of our national prosperity will surely be resumed without delay.

9. Let every good citizen, solicitous of the welfare of our country, do his best to accelerate the return to normal conditions by continuing his business operations without alarm and by assisting in the present movement to bring all the money now lying idle into active circulation, and all will be well.

INCREASE OF WEIGHTS ON LOCOMOTIVE DRIVERS.

Mr. H. W. Willie, assistant superintendent of the Baldwin Locomotive Works, presented a discussion on the steel rail specifications at the last annual meeting of the American Society for Testing Materials, which included some very interesting figures concerning the increase in total weight and weight on drivers of locomotives built at the Baldwin Locomotive Works for a period of 22 years. This data was presented in the form of curves for different classes of locomotives and showed that the increase in total weight, weight on drivers, and average weight per axle for the American type locomotive had increased steadily from 1885 to 1905, when it reached a maximum, and had since fallen off. All other classes are still increasing, although the percentage of increase is falling somewhat. The maximum average total weight for the American type was shown as 132,000 lbs.; average weight on drivers, 90,000 lbs.; and weight per driving axle 45,000 lbs. Similar data for 10-wheel locomotives shows that they have increased from 87,000 to 161,000 lbs. total and from 65,000 to 122,000 lbs. weight on drivers and from 21,900 to 40,600 lbs. per driving axle. Mogul or 2-6-0 type increased from 85,000 to 154,000 lbs. total, from 70,000 to 133,000 lbs. weight on drivers and from 23,500 to 44,000 lbs. weight per driving axle. Consolidation locomotives increased from 112,000 to 200,000 lbs. total, from 97,000 to 179,000 lbs. weight on drivers and from 23,250 to 44,750 lbs. weight per driving axle.

The maximum axle load in 1885 was 24,000 lbs. and in 1907 it was 53,900 lbs. The average axle weights of all types of locomotives has increased 112 per cent. in the 22 years.



ATLANTIC TYPE LOCOMOTIVE WITH WALSCHAERT VALVE GEAR—NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

ATLANTIC TYPE LOCOMOTIVES.

NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

On page 429 of the November issue of this journal appeared an illustrated description of a Pacific type locomotive, 30 of which have recently been put into service on the New York, New Haven & Hartford Railroad. In that article will be found a brief outline of the service for which those locomotives were designed, in which it was erroneously stated that the trains hauled by those engines were operated on a schedule of five hours between New York and Boston, a distance of 232 miles. The Pacific type locomotives are actually intended for service on the six-hour trains, weighing 550 tons or more, and for the five-hour trains, of which there are four each way, each day, an Atlantic type locomotive has been designed. The first order of twelve of this type is now being delivered by the American Locomotive Company.

The demand for these locomotives originated from the same causes as mentioned in connection with the Pacific type, that is, the lack of steam making capacity of the ten-wheel type, which has heretofore been used in this service, whenever it was necessary to increase the train above its normal weight.

These locomotives are duplicates of the Pacific type in many details and differ from that design, in addition to the wheel arrangement, largely in the following particulars: An extended wagon top type of boiler is used instead of the straight type; 2 in. flues are installed in place of 2¼; the flues are but 16 ft. 10 in. long in comparison with 20 ft. 6 in.; the cylinders are 21 x 26 in. instead of 22 x 28 in. and the drivers have a diameter of 79 in. in place of 73 in.

These changes are so inter-related as to give very nearly the same ratios as were obtained on the larger design. The reduction in size of cylinders and increase in diameter of drivers reduces the tractive effort to 24,700 lbs., which gives the same ratio of adhesion as is obtained with 31,600 lbs. tractive effort on the Pacific type. The cutting off of 3 ft. 8 in. in flue length, in spite of the increased number of flues, reduces the total heating surface by nearly 700 sq. ft., although the grate area remains the same. This has had the effect of slightly altering the ratios concerned with the heating surface and increases the B. D. factor from 587 to 597. The amount of heating surface per cubic foot of cylinder volume is reduced but slightly. In comparison with other locomotives of the same type it will be found that the ratios of the New Haven design approach very closely the average of the best designs in recent years.

The general dimensions will be found in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	24,700 lbs.
Weight in working order	200,000 lbs.
Weight on drivers	105,500 lbs.
Weight of engine and tender in working order	334,000 lbs.
Wheel base, driving	7 ft. 3 in.
Wheel base, total	28 ft. 2 in.
Wheel base, engine and tender	56 ft. 1 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.26
Total weight ÷ tractive effort	8.10
Tractive effort × diam. drivers ÷ heating surface	597.00
Total heating surface ÷ grate area	60.80
Firebox heating surface ÷ total heating surface, per cent	6.50
Weight on drivers ÷ total heating surface	32.40
Total weight ÷ total heating surface	61.30
Volume both cylinders, cu. ft.	10.40
Total heating surface ÷ vol. cylinders	314.00
Grate area ÷ vol. cylinders	5.15
CYLINDERS.	
Kind	Simple
Diameter and stroke	21 × 26 in.
VALVES.	
Kind	Bal. Slide
Greatest travel	6⅞ in.
Outside lap	1 3/16 in.
Inside clearance	⅛ in.
Lead, constant	5/16 in.
WHEELS.	
Driving, diameter over tires	79 in.
Driving, thickness of tires	3½ in.
Driving journals	10 × 12 in.
Engine truck wheels, diameter	36 in.
Engine truck, journals	6 × 12 in.
Trailing truck wheels, diameter	51 in.
Trailing truck, journals	8 × 14 in.
BOILER.	
Style	Ex. Wagon Top
Working pressure	200 lbs.
Outside diameter of first ring	67¼ in.
Firebox, length and width	108½ × 71¼ in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	F. 5, S. and B. 4 in.
Tubes, number and outside diameter	347—2 in.
Tubes, length	16 ft. 10 in.
Heating surface, tubes	3,041.3 sq. ft.
Heating surface, firebox	213.2 sq. ft.
Heating surface, total	3,254.5 sq. ft.
Grate area	53.5 sq. ft.
Smokestack, diameter	16 in.
Smokestack, height above rail	14 ft. 9½ in.
TENDER.	
Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	6,000 gals.
Coal capacity	14 tons

THE NATURE OF TRUE BOILER EFFICIENCY.

A paper by Messrs. W. T. Ray and Henry Kreisinger presented before the Western Society of Engineers, September 18, reviews the boiler tests which have recently been conducted by the Steam Engineering Division of the U. S. Geological Survey for the purpose of determining the laws governing the rate of heat absorption by boilers. The deductions drawn from these experiments as presented in the paper indicate that:

1. After the velocity of gas parallel to the heating surface has reached a certain value, which varies with the size of tubes and degree of temperature, the rate of heat absorption is almost proportional to the velocity.

2. The rate of heat absorption increases when the initial temperature rises; it also seems to vary directly with the density of the gas.

3. Increasing the diameter of flues decreases the efficiency of their absorbent power; increasing the length of flues beyond a certain limit, depending upon their size, increases their efficiency very little.

4. Most of the resistance to the passage of air through the flues is at the entrance into the tubes. The length of the flues increases the resistance but little.

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Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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THE ANNUAL INDEX.

We find that such a large proportion of our readers are having their numbers of this journal bound for reference that we have taken special pains this year to make the annual index as complete as possible, in order to facilitate reference to articles on any subject. The very complete sub-index of the New York Central Lines apprentice system articles will be appreciated by those who are specially interested in the apprentice question.

One is often quite disappointed after hunting up an article to find that it is a small note instead of an article of importance. In addition to our usual distinction between illustrated and non-illustrated articles we have therefore made a distinction between the non-illustrated articles of considerable length, the shorter ones, or notes, as we are accustomed to call them, the editorial comments and the communications. This, however, should not be taken to indicate that the shorter articles or notes are not of value, for quite often they contain a summary of the most important results from important investigations or discussions. We trust that our readers will find the improvements which we have made of convenience and practical value.

STEEL PASSENGER CAR DESIGN.

On page 210 of the June issue of this journal appeared the first and introductory article of a series by Charles E. Barba and Marvin Singer on the subject of steel passenger car equipment. Owing to causes beyond our, or the authors', control, the series was interrupted and the second article appears in this issue.

As far as we know this is the first elaborate treatment of this subject that has ever appeared. The authors are men who have had exceptional opportunities for becoming thoroughly conversant with steel car design, for both passenger and freight service and are treating their subject in an eminently practical manner. The present article introduces the subject of the underframe and thoroughly discusses all of its more important features. This will be followed by a very interesting graphical analysis of underframe stresses, which in turn will be followed by a most thorough and practical analytical treatment of the different types of underframe, giving the designer a practical illustration of the exact method of handling the subject. Future articles in the series will consider the design of the superstructure, interior fittings, exterior finish, lighting, heating, ventilation, etc., and will in all probability run throughout the coming year. We count ourselves exceptionally fortunate in being able to present so complete a treatment of this increasingly important subject.

SPIRAL TUBES IN SUPERHEATERS.

One of the characteristics of highly superheated steam is its poor conductivity of heat. This is an excellent feature after the steam has reached the cylinder, as it greatly assists in preventing condensation, the greatest loss of cylinder efficiency with saturated steam, but it works quite the other way in the superheater. There, in the smoke tube type, we have the steam flowing at a high velocity through a large number of small tubes, in each of which there is a film of steam in contact with the metal, which is highly superheated and acts as an insulation tending to prevent the transfer of heat to the center of the pipe. This necessitates holding the steam in the region of high temperature for a comparatively long time and hence the use of a large amount of superheating surface, in order to deliver highly superheated steam. The resulting disadvantages are not only the sacrifice of considerable boiler heating surface but also an increase in the number of joints and parts in the superheater. A design has recently been brought out in this country which takes note of this feature and by flattening the tubes, thus sending the steam through in a wide, thin jet, expects to increase the efficiency of the apparatus.

It would seem as if this difficulty could be largely overcome, and that a superheater could be designed which would deliver steam at a high temperature with considerably less total heating surface, by the use of either the spiral or Servé tubes, provided

that tubes of those types can be obtained to withstand the internal pressure. The former, by reason of the circular motion given the steam in each tube, would tend, by centrifugal action, to throw the steam at a lower temperature, which is necessarily heavier, toward the outside of the tube and thus continuallly break up the film of insulation above mentioned. The Servé tube would accomplish a similar result by conducting the heat to the center of the steam by means of the metal wings on the interior.

The trouble which will be caused by the chocking of a heater delivering water at a high temperature, particularly where water with much scale forming salts in solution is used, is the most serious feature to be considered. This makes it almost imperative to give it terminal attention every few trips. Probably the most practical way out of that difficulty would be to arrange the construction somewhat along the lines used in evaporators on ocean steamships where the nest of scaled tubes can be easily and quickly removed and replaced with a clean set.

VANADIUM STEEL.

Tests and practical experience have shown that the addition of a very small amount of vanadium to either carbon or alloy steel has a wonderful effect in improving the characteristics of the product. This effect is possibly most noticeable under conditions of alternate and repeated stresses, which, it is well known, will finally rupture the best steel, even though they singly be considerably below the elastic limit of the material. This condition, known as "fatigue," is amply allowed for in the design of axles and other parts subjected to alternate stresses, and in many cases results in very undesirable large sections because of the anxiety of the designer to surely be on the safe side. Even under these conditions, with apparently ample allowances, axles, main rods, etc., have been known to fail from this cause and the opportunity of obtaining a material offering large improvement in this respect will no doubt be rapidly taken advantage of.

Frame breakages are a source of constant trouble on practically all roads and even with careful records, covering long periods of time, it is almost impossible to locate the causes. As a matter of fact we know very little about the stresses in a locomotive frame and our designers are often compelled to go at it blindly, having only past experience, usually with lighter and differently arranged power, to guide them. The indications are that vanadium steel can be used to great advantage for this purpose. Its cleansing action will permit greater reliance to be placed upon steel castings, which, even if it did not result in other benefits, would greatly recommend it for railroad use. Having, however, as it does, a largely increased ultimate tensile strength, a higher ratio of elastic limit and a greatly improved dynamic resistance, makes it a material which our locomotive and car designers cannot afford to neglect.

In fact we believe that this latest development in the steel makers' art will prove to be of so great importance that we devote considerable space in this issue to an abstract of a paper by Mr. J. Kent Smith, which clearly explains what the material is and what it will do.

FEED WATER HEATERS.

The possibilities of a feed water heater look very attractive and it is altogether probable that eventually a successful device of this kind will be found on many of our locomotives. So far in this country, however, the efforts in this line have been largely confined to spasmodic attempts to heat the water in the tank by means of the air pump exhaust before it reaches the injector. Some saving can no doubt be made in this way, but the full benefits of hot feed water require much more than this. It should enter the boiler at practically the temperature of the water already there, or 388 degrees at 200 lbs. pressure, and thus require but comparatively little additional heat to convert it into steam and also cause no temperature strains in the boiler structure. That is the ideal condition and to attain it would probably introduce a more or less clumsy arrangement in the front end or a series of heaters such have been fitted by Mr. Trevithick to a locomotive on his road, shown in our November issue. Such an arrangement would not be looked upon with favor by American motive power officials and it is probable that the successful device will not attain ideal conditions. There is a broad gap, however, between tank heating and the ideal in which there is room for considerable study and experimenting. It should be remembered that a device which is going to require any great amount of attention at terminals, even if it does get over the road, will not be popular.

RAILROAD CLUB PAPERS

A group of mechanical department officials, while recently talking of railroad clubs, practically all admitted that papers that they had prepared for one or another of the clubs had been the means, at least to some extent, of considerably extending their acquaintance and getting them better positions. A college professor, from whom many of the younger men on our railroads have received instruction and inspiration, used to speak to his students somewhat in this manner, as they were about to be graduated. "Remember that it is just as essential for you to advertise yourself as it is for the manufacturer to advertise his wares. You can't very well do it in the advertising pages of the technical papers unless you are a consulting engineer. You can, however, advertise yourself and make your ability known to much better advantage by participating in discussions at railroad club meetings, by preparing papers to be read at such meetings, or by writing for the technical press. Don't attempt to take such action unless you have something of real value to impart."

A young man, who was regarded by his superiors in the mechanical department of one of our railroads as being of more or less promise, was asked to prepare a paper for the local railway club. He selected a subject which would have yielded much if carefully and patiently investigated, and which, if handled in this manner, would have undoubtedly attracted widespread attention. The records of the road were at his command, and higher officials and his associates would have been glad to have given him any assistance in their power. The paper, when presented, was a disappointment, for it treated the subject in a superficial manner and did not bring out any really valuable information, or make any suggestions as to improvements in general practice. It really hurt the young man. He never got any farther with the company he was with, although it had a special need for good men in positions to which he should have been eligible for promotion. Although this happened a long time ago the officials of the road in question still remember the incident and speak of it as an indication of the true worth of the man.

Another young man was notified one day that the railroad club was in sore straits, since a paper which had been promised for the next meeting, only two weeks away, would not be forthcoming. In spite of his youth and limited experience he was asked to help out by preparing a paper. It was at a time when his work and outside affairs were in such shape that he would have been justified in declining, but he felt that he had been honored by the request and determined to do his best to "make good." No midnight oil was spared and it is even said that his wife helped him in getting the article into readable shape. The paper was a success and abstracts of it appeared in practically all of the leading railroad technical papers. Attention was directed to the young man and it was not long before he was promoted to a more important position, and he found afterwards that his railroad club paper was to a large extent responsible for it.

It is not at all uncommon to find the executive committee, or secretary, of a railroad club more or less discouraged because of the difficulty of getting good papers. One would reasonably expect that the trouble would rather be to keep from getting too many, but this is not so. The technical editor is usually pictured as having his desk heaped high with first-class contributed matter, but this also is not true, in fact it is a most serious task to keep a steady supply of the right kind of material coming in. For instance, it has been the policy of this journal for many

years to try and bring out the younger men and encourage them to become contributors, but where 20 have been urged to do this not more than one or two ever respond. Three years ago the editor made a list of a dozen acquaintances in railroad mechanical departments, all young men of good education and more or less promise. After two years of systematically prodding them up, even going so far as to suggest subjects which certain ones were well qualified to follow up, the result was just one good article—and that from the busiest man in the lot, and he is certainly making good at the present time. The others are all doing well, but most of them seem to have fallen into a rut and appear to be "hiding their light under a bushel."

You say that the average mechanical department employee is overworked and has no business writing for clubs or technical papers, even if it is on his own time. Just take some subject with which you feel that you are familiar and sit down and try to prepare an article for publication and you will possibly find that there are a good many things in it that will bear still further investigation, and when the article is completed you will know considerably more about your subject than you did when you started. At any rate work of this kind does not apparently interfere with a man doing his full duty to the railroad company and making a success of himself, as you will discover if you will glance over the names of some of the contributors in the older files of this journal.

It is a mistake to prepare an article or to take part in a discussion unless you can impart something that will really help or inspire your readers or hearers. Say what you have to say in a few, clear cut, well chosen words. No matter how familiar you are with the subject it is a mistake to try to take part in a club discussion without some previous preparation unless you have had more or less experience in speaking extemporaneously, and even then things are often said which do not convey the correct impression and others are overlooked which should have been said.

Power Consumed by Electric Train Lighting.—The steam consumption with an engine driven electric lighting set in the baggage car, while the plant is in operation, is from 700 to 900 lbs. for eight-car trains, or approximately 100 lbs. per hour per car. The set operates from 8 to 10 hours a day and it may be taken at an average figure that about 900 lbs. of steam is consumed per day per car. With an axle driven set the average power absorbed from the axle throughout the run is between 2 and 3½ horse power per car, depending upon the character of the car and the system used. For extended lines overland this continues for twenty-four hours of each day and consequently 48 to 60 horse power hours are consumed. Assuming 30 lbs. of steam per hour consumed by the locomotive per horse power at the car axle, the axle driving set will consume from 1,500 to 1,800 lbs. of steam every twenty-four hours. When, however, the run comprises only the time of a single night or less, instead of extending over twenty-four hours, the advantage very rapidly turns toward the axle driven equipment.—*Dugald C. Jackson, before the Western Society of Engineers.*

The Properties of Malleable Cast Iron.—Malleable cast iron consists almost entirely of ferrite and temper carbon. It has a tensile strength of from 40,000 to 60,000 lbs. per square inch, with an elongation of from 2½ to 5 per cent., which in special cases may go as high as 8 per cent., and a reduction of area of 2½ to 8 per cent., and may go as high as 12 per cent. A one-inch bar on supports 12 in. apart should bear a load at the center of at least 3,500 lbs. and be deflected at least ½ in. before breaking. Thin sections should be capable of being flattened out under a hammer and bent double without cracking.—*Bradley Stoughton in "School of Mines Quarterly."*

High Speed Boat.—The British torpedo boat destroyer, "Mohawk," according to press dispatches, maintained a speed of 34¼ knots, or nearly 40 miles per hour for six hours during its speed trials on November 15.

ELECTRIFICATION OF THE ROCHESTER DIVISION OF THE ERIE RAILROAD*

The first installation of the single phase alternating current system of electric motive power upon a steam railroad, to go into commercial operation, was a portion of the Rochester Division of the Erie Railroad, which was opened on the 18th of June. This, in addition to being the first to operate single phase cars on a steam railroad, was also the first to use 11,000 volts working pressure commercially on a trolley in this country, having preceded the New Haven System in both of these respects by a few weeks. It is also the first instance of a heavy electric traction system receiving power from a 60,000 volt transmission line. All of the construction of this system, except that of the 60,000 volt transmission line and the car bodies and trucks, was designed, executed and placed in operating condition by Westinghouse, Church, Kerr & Co., engineers.

The section of track electrically equipped is 34 miles long, extending from Rochester, N. Y., over the main line of the Rochester Division, to Avon, a distance of about 19 miles, thence 15 miles over the Mt. Morris branch. The railroad is entirely single track with sidings at way stations, averaging three or four miles apart. The grades are light and the curvature for the most part quite easy.

The line was originally laid with 68 lb. rails, but was re-laid with 80 lb. rails just prior to the electrification. A single No. 2/0 protected rail bond is applied to each rail joint under the plate. Because of the high tension system comparatively light rail bonding is possible.

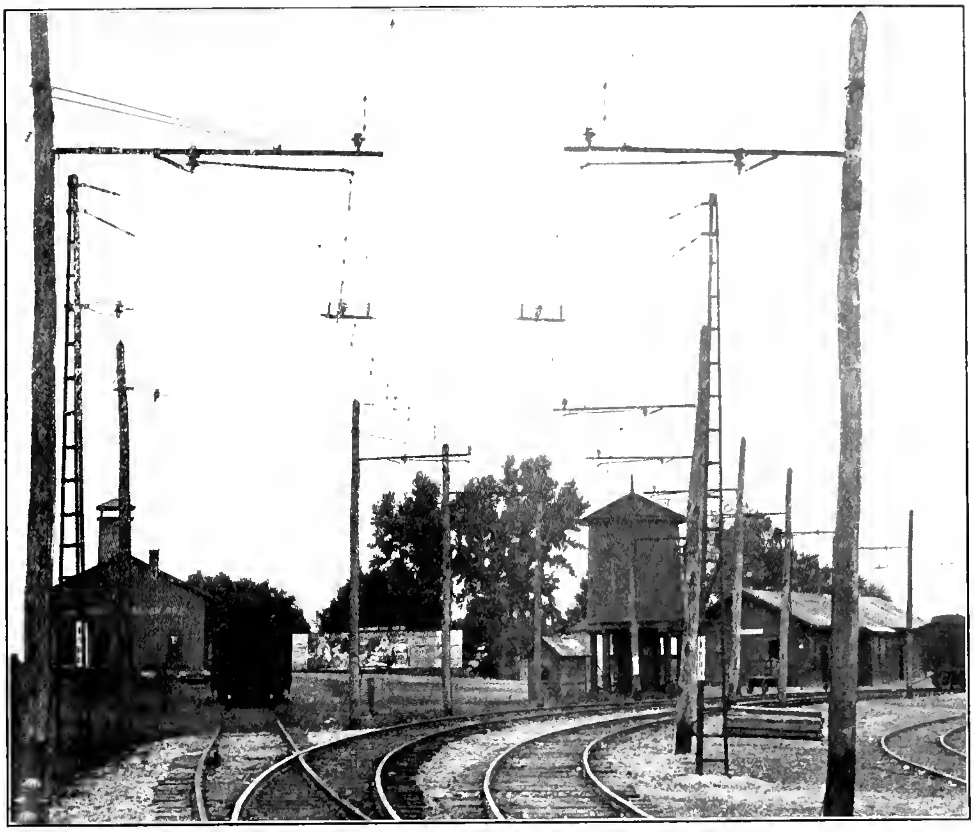
The electric service is devoted wholly to passenger traffic, which is of the local interurban type. The freight service is handled exclusively by steam locomotives, as heretofore, as are also the through passenger trains. The steam service between Rochester and Mt. Morris originally comprised three round trips daily. The electric service has permitted six round trips daily between Rochester and Mt. Morris and three more between Avon and Mt. Morris.

Power Supply.—The power is generated at Niagara Falls in the plant of the Ontario Power Company and is transmitted at 60,000 volts, three phase, over the lines of the Niagara, Lockport and Ontario Power Company, which crosses the Erie Railroad at Mortimer. From this point a branch line was constructed to Avon, being located upon the railroad right of way for nearly the whole distance. This line was carried upon poles of the A frame type, using two 40 ft. cypress poles set abreast of each other, and inclined so that their tops are framed together. The cross arm consists of two 3½" x 6" x 8 ft. timbers, the insulators being located one on either end of the cross arm and at the apex of the poles, so that there is an equilateral spacing of 7 ft. between each of the three wires. Lightning protection was installed upon every fifth pole. The conductors are of No. 4, hard drawn, stranded copper cable, the standard length of span being 220 ft., which is shortened on curves where necessary.

Substation.—The single substation required for this installation is located at Avon, and together with the car inspection shed is adjacent to the roundhouse and division repair shop at this point. The walls of the building are of brick, resting on concrete foundation, the roof and floor being of reinforced concrete. The floors are supported upon steel beams, but the roof beams are of reinforced concrete. This building measures 39 ft. 8 in. by 44 ft. on the outside and is 29 ft. 10 in. high from the top of the foundation to the top of the parapets.

The basement of the building contains one of the transformer oil tanks and an oil pump. The main floor is divided into three rooms, the main transformer room being 43 x 17 ft. and extending the full height of the structure. The remaining space of the main floor is divided into a high tension room, through which the 60,000 volt circuit enters and an operating room where all of the 11,000 volt switching apparatus and measuring instruments are located. Over the operating room is a mezzanine

* Based on an extensive descriptive article prepared and furnished by Mr. W. N. Smith, electric traction engineer, Westinghouse, Church, Kerr & Co.



VIEW SHOWING BRACKET AND SPAN CATENARY TROLLEY SUPPORTS—ERIE ELECTRIFICATION.

floor on which is located the 11,000 volt lightning arrestors, the 60,000 volt choke coils and the 60,000 volt series coils. The arrangement of these rooms and circuits is shown in one of the illustrations.

The transmission line terminates at the lightning arrestor yard in the rear of the substation, where an arrangement of 60,000 volt lightning arrestors is provided. From this the three high tension conductors enter the substation through glass discs held in 36 in. tile set in the upper portion of the rear wall of the substation. The circuit after entering the station passes through three circuit breakers mounted directly inside of the rear wall, thence over bare copper conductors to the three oil insulated choke coils on the mezzanine floor, thence to three oil insulated series transformers, from which connections are taken to the power measuring instruments in the operating room. The main connections finally terminate upon a set of copper bus bars in the transformer room, which are supported upon porcelain insulators mounted on wooden cross arms and placed at a convenient height directly over the transformers.

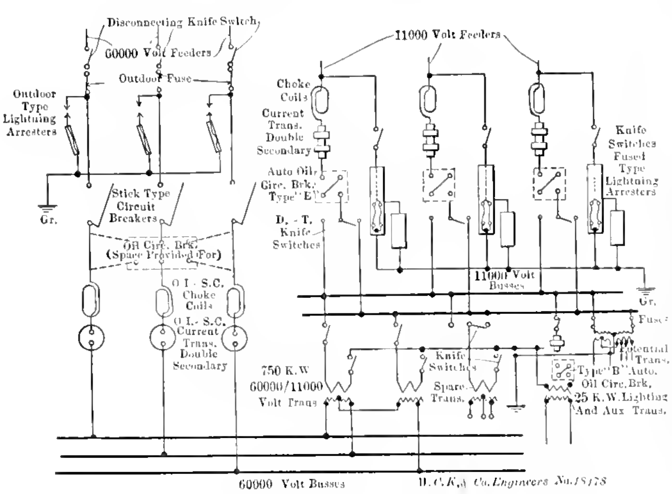
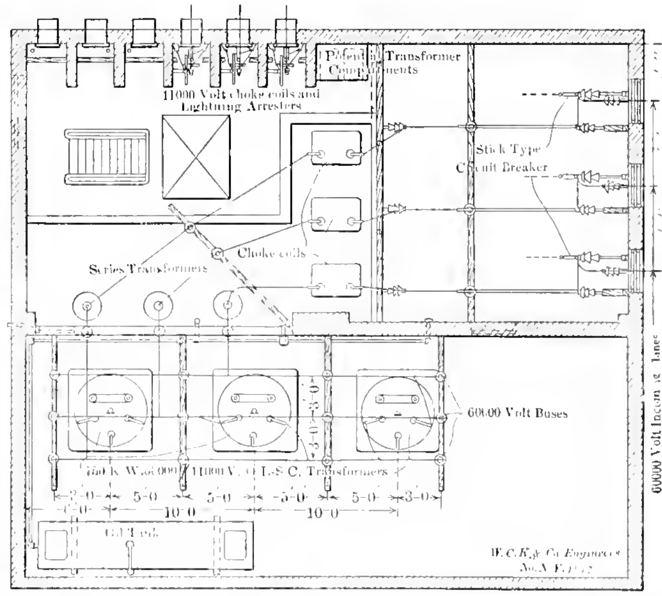


DIAGRAM OF CIRCUITS IN SUBSTATION.

This three phase current is rendered available for single phase distribution by means of three transformers of the Westinghouse oil insulated, water cooled type, each of 750 k. w. capacity. The high tension connections are such that in case one transformer fails while in service its connections can quickly be taken off the bus bars and put on the spare transformer, there being but two in regular use. The low tension windings are so connected that either 11,000 or 22,000 volts can be obtained. This has been so arranged on the possibility that, at some future time, it might be desirable to transmit current for a distance of 40 or 50 miles to another substation.

The current is transformed from three phase to two phase and the electrified line is divided into two sections, each of which uses one phase of the current. Either the T or V connection



PLAN OF SUBSTATION SHOWING LOCATION OF INSTRUMENTS.

in [illegible] the latter method, however, being employed at present, arrangements have been made for conveniently removing a transformer or its coils, by the installation of a transfer track and a 10-ton hand hoist. Two cylindrical boiler iron tanks are provided, each being of slightly greater oil capacity than a single transformer. One of these is located in the basement directly under the transformer room, so that the oil can readily be drawn into it. The other is suspended from the concrete roof beams at the top of the room and acts as a reservoir for distributing oil back in the transformer. The oil is pumped from the lower to the upper tank by means of a steam pump, the steam supply being obtained from the adjacent roundhouse. By this arrangement it is a simple matter to draw the oil off from any transformer, if its insulating qualities are found to have depreciated, and a de-hydrating, filtering or purifying apparatus can readily be employed with the aid of a pump, and the supply returned again to storage.

The water circulation in the transformers is by gravity, the supply coming from the roundhouse water tank. There are three separate water cooling coils in each transformer case, each one controlled by its own valve, so that the amount of water can be varied as found necessary under the varying conditions of load.

The 11,000 volt bus bars run along the wall of the operating room, the circuit passing from them through oil circuit breakers, of which there are three, one being a spare, and thence to the mezzanine floor and through two low equivalent lightning arrestors and out through the substation wall.

Call bell circuits have been provided so connected that when a circuit breaker opens or the temperature of any transformer runs above normal, a bell is rung in the adjoining car inspection shed. The station itself does not require the constant presence of an attendant and it has been found that an average of one hour a day is all the attention needed.

Catenary Trolley Construction.—Nearly all of the line construction is of the bracket type, except over the railroad yards at several stations, where span construction is used. Chestnut poles, averaging 25 in. in circumference at the top and about 42 in. at the butt, and between 35 and 40 ft. long, are used. The poles are given about 12 in. rake and are tamped with cobble stones. The brackets consist of a 3 x 2½ in. T-iron 10 ft. long, the heel of which is fastened to the pole by a pair of bent straps, the other end being supported from the pole top by two ⅝ in. steel truss rods. These rods are attached about 27 in. back from the outer end of the bracket and run on either side of the pole to a clamp which grips the top instead of requiring the bolt or truss rod to pass through the wood. When necessary, extra long brackets are employed and an extra set of truss rods are provided. The insulator pins are of malleable iron and grip the flange of the T-bracket. On these are mounted insulators, 6⅞ in. diameter and 6 in. high, of the three petticoat type, being made in two parts. These insulators were specially designed for this installation.

The insulator pins are located ordinarily about 12 in. from the ends of the bracket, although their location can be varied to suit the alignment of the tracks.

The messenger wire is of "extra high strength" steel in seven strands and is 7/16 in. in diameter. The trolley wire is No. 3/0 B and S grooved copper.

The spans on straight line track are 120 ft. in length, and as much shorter as required on curves. The maximum deflection allowed from the center line of the track is 7 in. each way. The catenary hangers are of the drop forged type, the messenger clip and trolley clip being of the same type, but grooved differently to accommodate their respective wires. They are joined by a ⅝ in. hanger rod with right hand threads on each end, the longer rods being flattened in the middle to admit of bending, so as to conform to the divergence of the messenger and trolley wires near the ends of the span. The hangers are spaced about 10 ft. apart. Both the trolley and messenger ears are secured in position by jam nuts. The steady strain rods are of treated wood and are mounted on one side of the bracket, instead of directly underneath it, in order to give sufficient clearance for the pantagraph trolley on curves. These rods are hinged to porcelain strain insulators, which are clamped to one side of the bracket and can be shifted along it to follow up any change that may be required in the alignment of the trolley wire. Steady strains are used only on curves and turnouts and were not found necessary on tangent tracks.

Every trolley bracket is grounded to the rail so that an insulator failure will instantly throw off the power, and minimize the danger of setting the wooden poles on fire. The burning of a wooden pole would not itself necessarily cripple the electric service, but it would be quite likely to cause a dangerous obstruction to the passage of steam trains.

The span construction is, as nearly as possible, similar to the bracket construction, and uses the same type of pin and insulator. A piece of 3 x 2½ in. T-iron about 30 in. long is suspended from the span wire by adjustable hangers and the messenger wire rests upon the insulator the same as in the regular bracket construction. At several points special construction, which varies somewhat from the standard, was required.

A simple type of pull-off was devised for curves in span construction, which consists of a spool type insulator with a piece of piping cemented through the center, this pipe being slipped over the hanger spacing rod joining the messenger and trolley clips. This gives an insulating connection through which an ordinary pull over cable can be attached to both messenger and trolley wires wherever required and the division of the pull between the two wires can be easily adjusted to suit the conditions.

Only part of the line has been equipped with lightning arrestors. These are of the swinging fuse gap type of construction, made by the Westinghouse Electric & Mfg. Co. This type of arrestor consists of a gap, one side of which is connected directly to the trolley and the other to the ground. The latter connection being through a fuse enclosed in a tube, which, while the fuse is intact, is mounted in an inclined position, but when the fuse is blown, a latch is raised and allows the tube to swing to a vertical position. This difference in the position of the tube is easily seen from the ground and the blown fuse tube can be lifted off the suspending lugs by a pair of insulating tongs made for the purpose and the fuse renewed and replaced in a few moments.

The trolley line is divided into seven sections which are separated by trolley section insulators. These are of the overlapping type, made of impregnated wood of sufficient length to insure insulation at 11,000 volts. One of these breakers opposite the substation at Avon, differs from the others in that it is not of the overlapping type, since it is necessary at this point to absolutely separate the two halves of the trolley line in order to utilize the separate phases of the trolley current in each half.

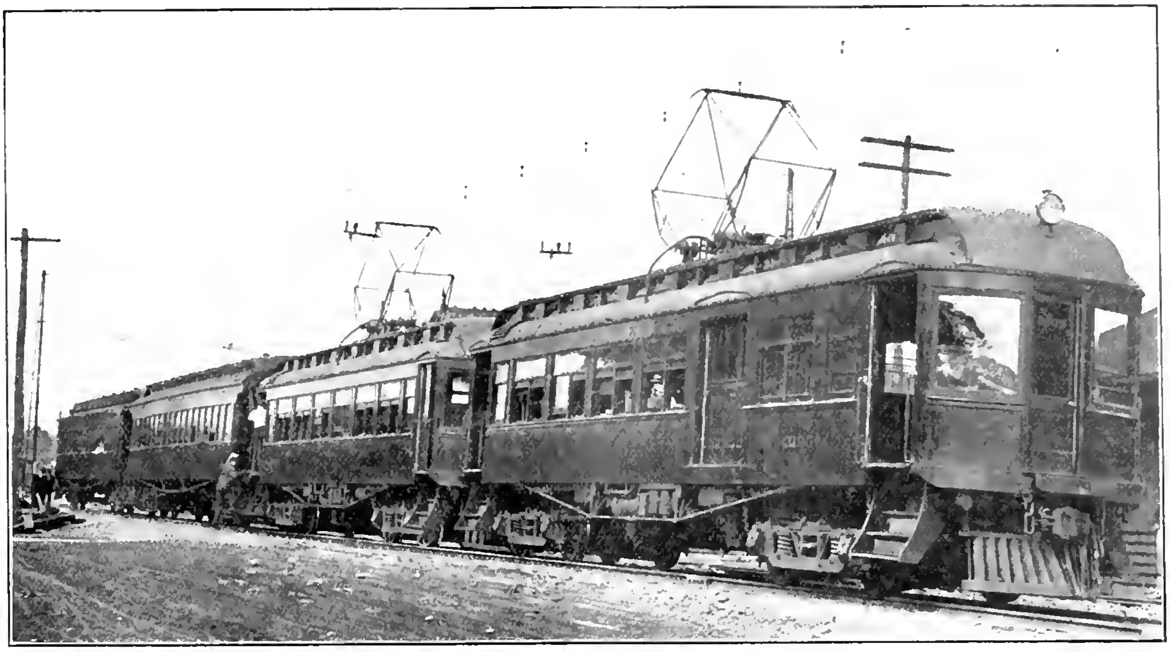
The only feeders necessary are those connecting the substation with the trolley on opposite sides of this section break. The principal object of cutting the trolley into additional sections is to facilitate the locating of line troubles.

Electric Cars.—At present there are but six cars equipped with electric apparatus in service on the electrified section. It is expected, however, that this number will be increased in the near future. These cars were built by the St. Louis Car Company and measure 51 ft. 4 in. over bumpers. Four of them are arranged in two passenger compartments and the other two have a baggage compartment in addition, with smaller seating compartments.

The construction is of composite steel and wood underframing with truss rods and a wooden superstructure. They are fitted with large vestibules and the end doors of the car are of the sliding type. The vestibule side doors are also of the sliding type and a double acting swing door is arranged in each vestibule so as to form a motorman's compartment, or if in the center or rear of the train, to be folded back to enclose the control apparatus and brake gear.

Each car is fitted with a 50 candle power headlight at each end on top of the hood, and each also has a gong, air whistle, and standard train air signal apparatus. The cars have standard M. C. B. couplings, air hose connections, etc., so as to couple with any of the standard steam rolling equipment.

The trucks are of the standard M. C. B. swing bolster type



SINGLE PHASE ELECTRIC TRAIN ON THE ERIE RAILROAD.

with inside hung brake beams. The wheel base is 6 ft. 8 in. and the axles are 6½ in. in diameter.

The electrical equipment of the cars consists of four Westinghouse single phase railway motors with a normal rating of 100 h.p. each driving the axles through gears, the gear ratio being 20.63. The suspension is of the nose type and solid gears are pressed upon the axles. The control system is of the Westinghouse electro-pneumatic type and includes three distinct circuits: the high potential, low potential and the control circuit.

The high potential circuit includes only the pantagraph trolley, a line switch and the high potential coils in the transformer. The low potential circuit includes the switch group, the preventative coils, the reverser and the motors. The control circuit includes the master controller, one in each vestibule, the train

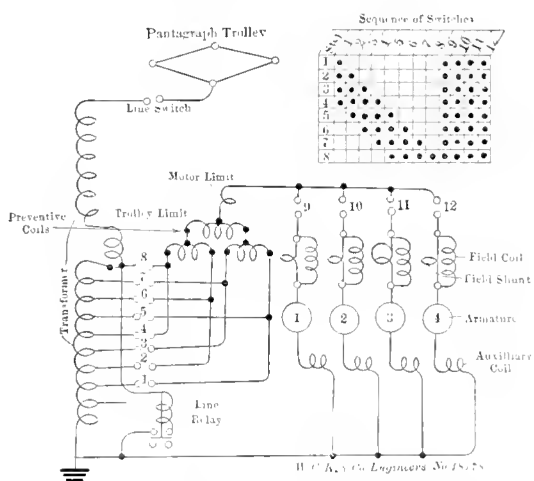


DIAGRAM OF HIGH AND LOW POTENTIAL CIRCUITS ON MOTOR CARS

line wires, the valve magnets, and interlocks the storage battery supplying the current in this circuit and a motor generator set, which is used either to charge the batteries or to actuate the control system. The high potential circuit is at a pressure of 11,000 volts, the same as the trolley; the low potential circuit has various voltages, corresponding to different taps on the transformer and controlled by the switch group, and the control circuit is at a pressure of 15 volts.

The pantagraph trolley mechanism is operated by a pair of springs and an air cylinder. The trolley is raised and held against the wire by means of the springs and is lowered by the application of air pressure in the cylinders which form part of its base. When down, it is automatically locked and the latch of this lock can only be withdrawn by applying air pressure to another small cylinder, which will release it and allow the springs to raise the trolley. This trolley mechanism is so connected with the control circuit that any interruption in the supply of the high tension current or the opening of the line switch or main circuit breaker immediately causes the trolley to be lowered.

The line switch is operated by air pressure admitted by electrically operated valves and in case the supply of air has been exhausted, as when the car has stood for some time unused, a small automobile tire pump, placed underneath one of the car seats and connected into the trolley air piping system, is provided and enables the air operated control latch to be withdrawn, the trolley raised and power obtained that will start the air compressor. The line switch must be held in mechanically until the air compressor has furnished a pressure of 50 lbs., which is sufficient to properly actuate the control system.

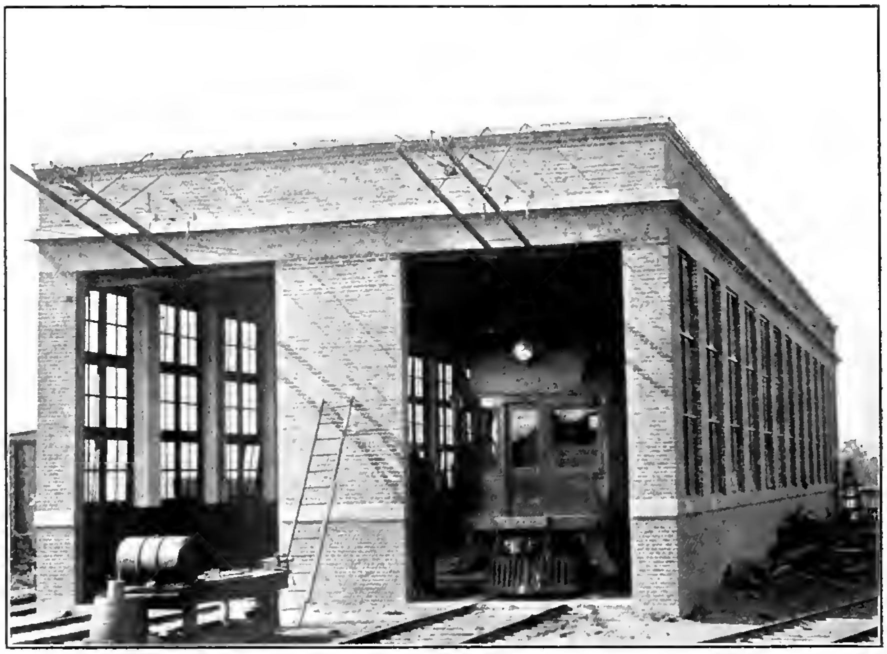
The transformer is of 200 k. w. capacity and of the oil insulated type. It has three high potential and eight low potential taps, the latter running down as low as 110 volts, which pressure is used for heating, lighting and auxiliary purposes. The switch group consists of a set of air operated switches, controlled by magnet valves, all mounted in one frame. The switches are all provided with interlocks, which automatically give the connections in such a way that each switch of the group acts only when the current in the motors has reached a pre-determined value, thus making acceleration automatic. There are two reverser switches actuated by air pressure, one for each pair of motors. The current from the main motor circuit is led through the motor limit switch, which makes effective the functions of the interlocks and renders it impossible for the successive switches to be thrown in unless the limit switch is closed.

The master controller makes the proper connections by means of which the 15 volt control circuit actuates the valve magnets which control the action of the air operated main contactors in the switch group and the reversers. The control handle is normally held in a vertical central position by springs, unless it is moved to one of the running points by the motorman. When released it returns to a vertical position, shutting off the power and enabling the emergency application of the brakes by means of the brake relay valve alongside of it. There is a push button on each side of the master controller case. The one on the right side when pressed drops the trolley and opens the line switch. When the button on the left hand side is pushed the switch group is stepped up to the last or high speed notch and

remains in that position until the handle of the controller has been returned to an off position.

In one vestibule is located a slate switchboard panel enclosed in an asbestos lined compartment, with steel doors, upon which are carried all of the switches and fuses for the control of the battery, motor generating set, lighting circuit, heaters and the main connection from the transformers and the auxiliaries.

Car Inspection Shed.—Adjacent to the substation has been constructed a brick building 136 ft. 6 in. long by 30 ft. 5 in. wide, which will accommodate four cars. The general style of construction is similar to that of the substation. Two tracks run clear through the building, and the openings are enclosed by rolling steel doors. One of the tracks is provided with a pit. A third track, not connected with the outside, is situated in the middle of the building between the two car tracks and a transfer table is located in a cross pit situated about midway in the building, by means of which a truck may be removed from a car and transferred to the center track. A trolley hoist running across the building over all three tracks, and located near one end, is also provided. The pits and building are thoroughly lighted by incandescent lamps and extension plugs have been installed where required. The building is equipped with water, steam and compressed air service.



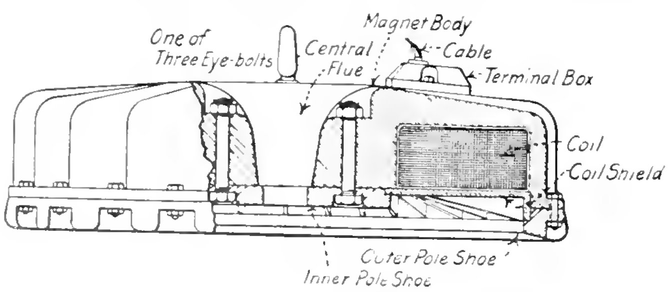
CAR INSPECTION SHED AT AVON—ERIE RAILROAD ELECTRIFICATION.

The facilities offered in this inspection shed are supplemented by the regular division repair shops located near by.

Operation.—The car equipment was designed to maintain an average schedule speed of 24 miles per hour with a single car, making one stop per mile over the entire road. Also, with a motor car and one trailer, it is to maintain the same schedule speed with stops about 2½ miles apart. Shelters have been provided where highways cross the line, there being 22 of these flag stations. In addition there are six regular intermediate way stations where all trains stop or a total of 28 stations where electric cars may be required to stop. The experience so far has shown that electric trains can be depended on to keep their running schedule very closely.

LIFTING MAGNETS.

Lifting magnets are being used to splendid advantage at several railroad shop plants in connection with the handling of scrap, boiler plate, castings, etc. No time is lost in adjusting hoisting tackle, and this is specially advantageous in connection with the handling of irregular shaped castings and machined parts. It is only necessary to lower the magnet over the mate-



CUTLER-HAMMER LIFTING MAGNET.

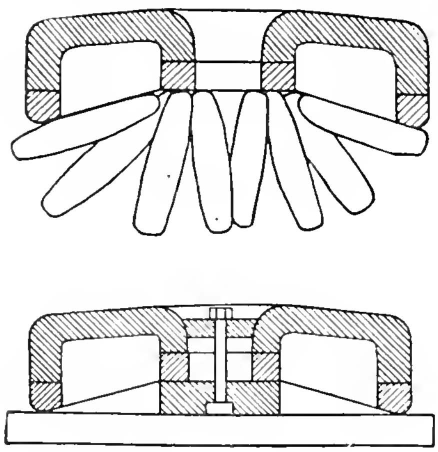
[illegible] on the current, and lift. The magnet will pick [illegible] at the same time, depending upon the nature of [illegible] the size of the magnet. It will handle metal too h[illegible] the hand.

Under [illegible] conditions a 50 in. Cutler-Hammer magnet will lift as mu[illegible] tons, while under adverse conditions it might not be ab[illegible] lbs. At a test, conducted by the Youngstown Sheet & Tube Company, Youngstown, Ohio, one of these 50 in. magnets unloaded a steel gondola car containing 109,350 lbs. of full size sand cast pigs, in two hours and five minutes. In doing this the service of only one man was required—the crane operator. The detail data for this test is as follows:

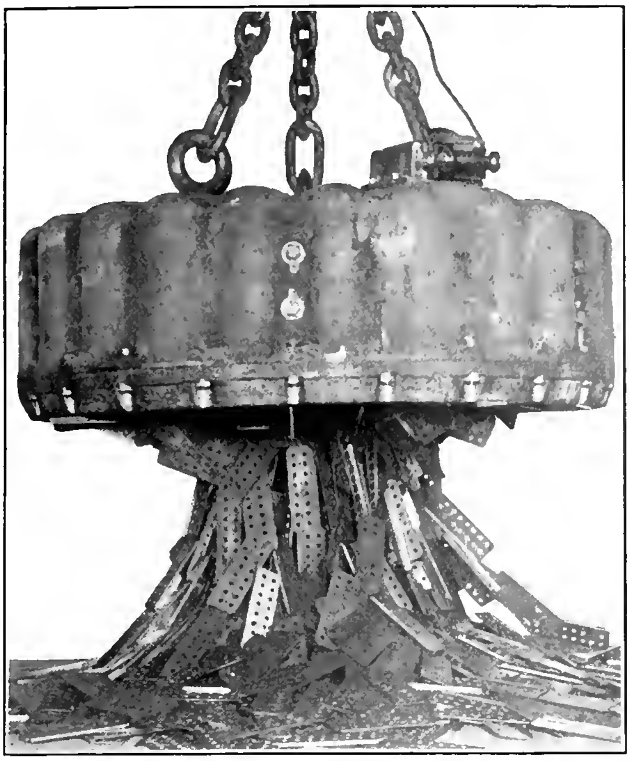
Total weight of pig iron unloaded from steel gondola	109,350 lbs.
Weight of average lift (including "lean" lifts when cleaning up car)	785 lbs.
Trips required to empty gondola	139
Current on magnet	1 hr. 15 min.
Current off magnet	50 min.
Time consumed in unloading gondola	2 hrs. 5 min.
Current required to energize magnet	30 amperes at 220 volts

On a basis of three cents per kilowatt hour, and this is high, the cost of the electric current required during the test would have been less than twenty-five cents.

The construction of the magnet depends upon the form of the material to be handled. Magnets for handling plates, rails, tubes and similar material are usually made rectangular in shape, although in some cases the circular form answers as well, and are preferably operated in pairs, the two magnets being placed on a balancing bar to which the crane hook is attached. Magnets for handling pig iron, "skull" crackers, or the "skulls" themselves, are usually circular in form and are constructed with a much greater lifting capacity than those designed for handling plates, tubes, etc.



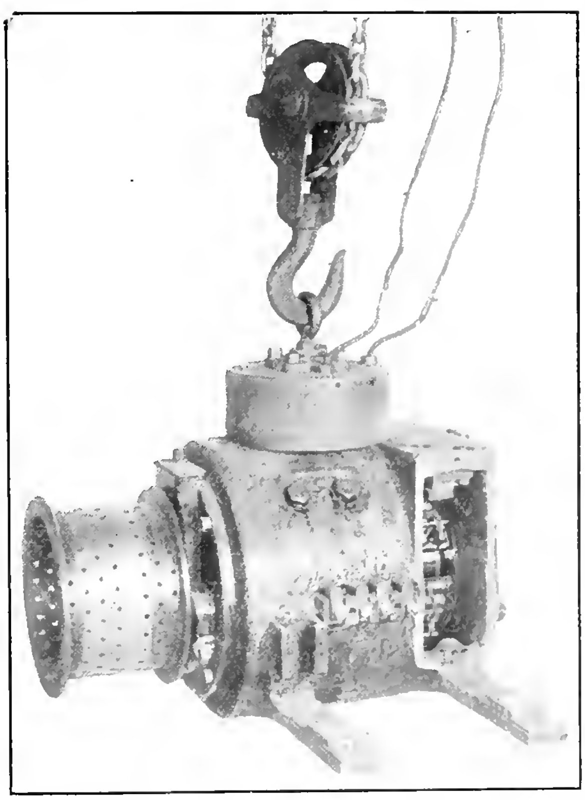
THE CONCAVE FACE MAGNET IS SPECIALLY ADAPTED FOR HANDLING SMALL PIECES AND PIG IRON. WITH THE AUXILIARY POLE PIECE ATTACHED, LONG OBJECTS WITH PLANE SURFACES ARE HANDLED EQUALLY WELL.



LIFTING SMALL PIECES.

A 50 in. Cutler-Hammer magnet weighs about 5,000 lbs. and consists of a hollow steel casting in which a magnetized coil is placed. This coil is carefully built up of alternate layers of copper and asbestos and is insulated from the cast steel frame by thick sheets of mica. No combustible material of any kind is used and the magnet cannot be damaged if it is accidentally left in circuit over night.

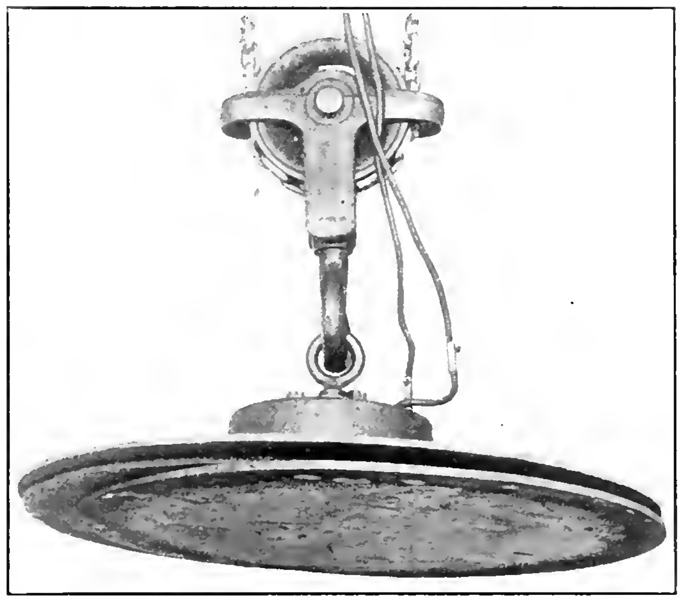
In the design of these magnets the magnetic attraction of the inner pole has been purposely made stronger than that of the outer one. In handling pig iron or similar material the bulk of the pieces constituting the lift are therefore drawn toward the center of the magnet, thus enabling the operator to drop the load within a much smaller area than is possible where the flux is so distributed that the pieces of metal cling to the outer edge of the magnet frame.



10 INCH MAGNET LIFTING AN 800 LB. BLISS ELECTRIC CAR LIGHTING GENERATOR.

The corrugation of the magnet frame provides a greater surface for heat radiation and at the same time forms niches that protect from injury the heads of the through bolts which fasten the removable pole shoe to the magnet frame. The important consideration of heat radiation is further aided by the simple expedient of casting the magnet frame with a central aperture through which air may freely circulate. This prevents the formation of a pocket of dead air in the concave under face of the magnet, and in addition to forming a ventilating flue, reduces the weight of the magnet.

Lifting magnets of large size, designed for use with pig iron, scrap, etc., are made concave on the under side, because this form is best for handling large numbers of irregular shaped pieces of metal at a single lift. When, however, the load consists of ingots or other large objects with plane surfaces, this concavity becomes objectionable, since an air gap intervenes between the inner pole and the object to be lifted. The above mentioned central aperture in the magnets makes it possible to convert them in a few moments from concave faced magnets into magnets adapted for handling large masses of metal with plane surfaces.



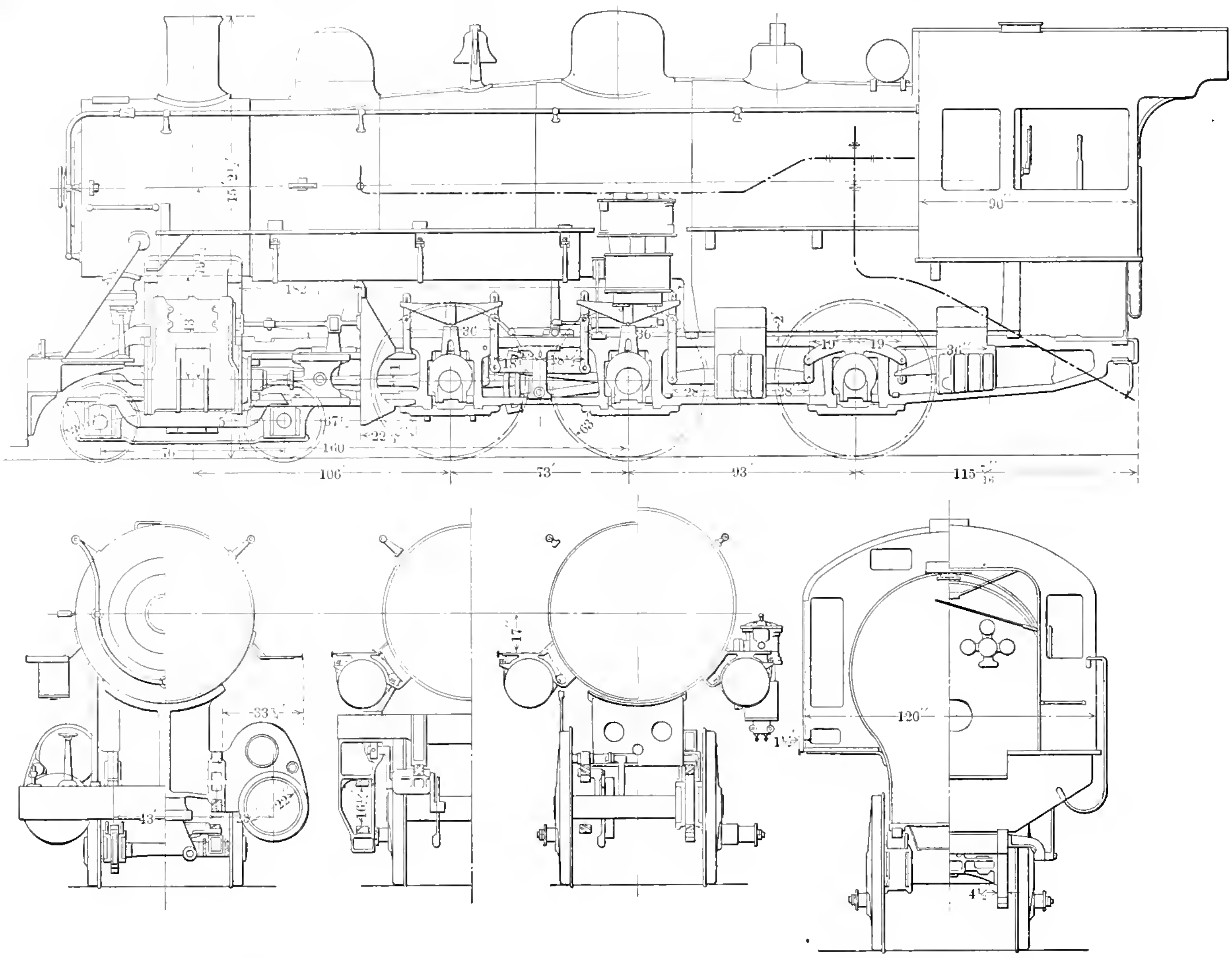
10-INCH MAGNET HANDLING TANK HEADS.

This is accomplished by inserting in the central aperture an auxiliary pole piece so proportioned as to extend the inner pole downward to the level of the outer pole, thus eliminating the air gap and insuring intimate contact of both poles with the object to be lifted.

The pole shoes, which are of course subjected to the greatest wear and tear, are removable, and can readily be replaced when necessary. An improved form of terminal box has been adopted, consisting of a solid casting, doing away with the projecting handle formerly used, which was liable to breakage. The new box is also water tight.

When the circuit is suddenly opened on a magnet coil there is a strong inductive reaction, or "kick," the effect of which is to induce a high voltage at the terminals of the coil. Constant repetitions of this "kick" will sooner or later break down the strongest insulation unless provision is made for guarding against it and dissipating the energy outside of the coil itself. In the Cutler-Hammer system of control the force of the inductive reaction, incident to the opening of the circuit, is minimized by having a discharge resistance automatically shunted across the magnet terminals just prior to the opening of the magnetic circuit, this resistance being disconnected automatically prior to the re-establishment of the magnetic circuit.

These lifting magnets are furnished in any size from 10 to 50 in. by the Cutler-Hammer Clutch Company, Milwaukee, Wis.



ELEVATIONS AND SECTIONS OF TEN-WHEEL OIL BURNING LOCOMOTIVE—SOUTHERN PACIFIC CO.

TEN-WHEEL PASSENGER LOCOMOTIVE.

SOUTHERN PACIFIC COMPANY.

The Baldwin Locomotive Works has recently completed an order of twenty ten-wheel locomotives for the Harriman Lines, which have been consigned to the Southern Pacific Company. These locomotives are equipped for oil burning and are the heaviest and most powerful of this type on our records. They weigh over 203,000 lbs. total, of which nearly 160,000 lbs. is on drivers. This gives an average weight per axle of 53,250 lbs., which is unusually large for a ten-wheel locomotive and is above the average modern locomotive of any class. The greatest weight per axle of any locomotive on our records is 58,600 lbs. and the previous maximum for ten-wheelers is 51,333 lbs.

It will be remembered that in 1903 the Harriman Lines adopted a very complete set of standard designs for locomotives,* which included designs for Atlantic, Pacific, light and heavy consolidation, mogul, and six-wheel switching, but did not include a design of ten-wheeler. The present locomotives were built from designs furnished by the railroad company and can be considered as an extension of the common standards, and, although they differ in many particulars from the previous engines, the details wherever practical have been made interchangeable with them.

These locomotives have a tractive effort of 34,700 lbs. and are intended for service over the heavy grade division between Sacramento, Cal., and Sparks, Nev., a distance of 158 miles. The first 22 miles of this division is of comparatively light grade and one of the locomotives has been designed to maintain an average speed of 27½ miles per hour with a 500 ton train. From this point for the next 30 miles the grade is much heavier, having a maximum of 105.6 ft. per mile, and a helper locomotive will be required to maintain a speed of 21.3 miles per hour with the same train. For the next 53 miles, the larger part of which is on a grade of 116 ft. per mile, the average speed with two locomotives will be 16.7 miles per hour.

At this point, 105 miles from Sacramento, the summit is reached and the remainder of the trip is down grade.

The most noticeable change in the common standard design of previous locomotives is found in the boiler, which is of the wagon top type, 72 in. in diameter at the front and contains 355 2 in. tubes. It is of the narrow fire box design, since it is to be used for burning oil and there is no necessity for a large grate area. The mud ring is 5 in. wide on all sides and the water spaces around the fire box have been liberally increased toward the crown sheet.

The general features of design are well illustrated in the drawings and photograph given herewith and the general dimensions, weights and ratios are shown in the following table:

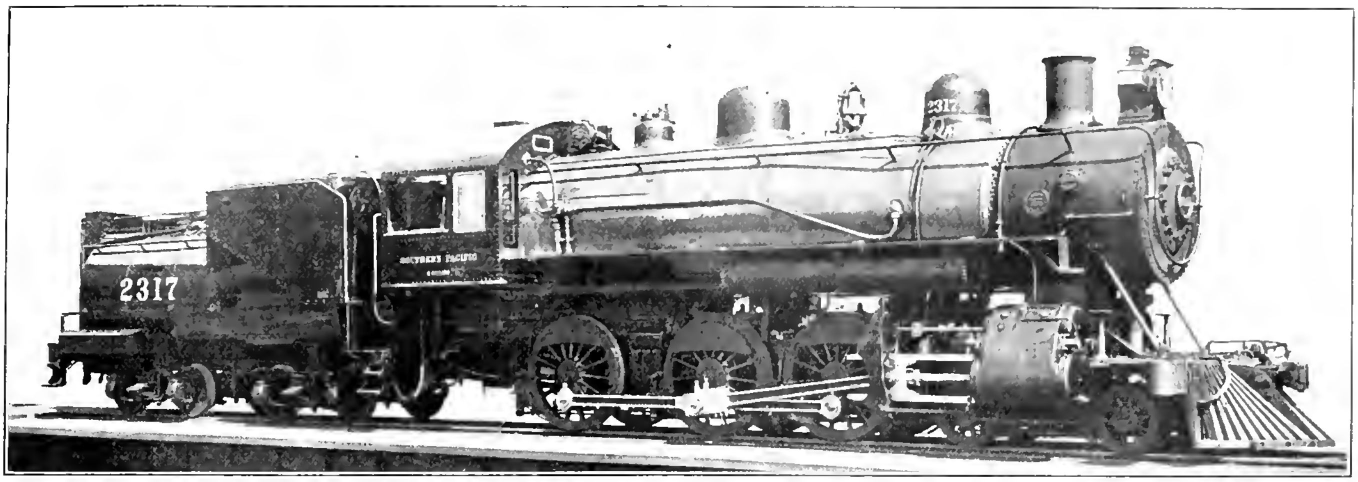
GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Oil
Tractive effort	34,740 lbs.
Weight in working order	203,050 lbs.
Weight on drivers	159,750 lbs.
Weight on leading truck	43,300 lbs.
Weight of engine and tender in working order	344,000 lbs.
Wheel base, driving	13 ft. 10 in.
Wheel base, total	25 ft. 10 in.
Wheel base, engine and tender	58 ft. 10½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.58
Total weight ÷ tractive effort	5.85
Tractive effort × diam. drivers ÷ heating surface	730.00
Firebox heating surface ÷ total heating surface, per cent	6.87

* See American Engineer, 1903, pp. 151, 200, 250, 288, 322, 353, 400 and 411.



POWERFUL TEN-WHEEL OIL BURNING LOCOMOTIVE—SOUTHERN PACIFIC COMPANY.

Weight on drivers ÷ total heating surface	53.30
Total weight ÷ total heating surface	68.00
Volume both cylinders, cu. ft	12.30
Total heating surface ÷ vol. cylinders	243.00
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 × 28
Kind of valves	Piston
Diameter of valves	12 in.
WHEELS.	
Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 × 12 in.
Driving journals, others, diameter and length	9 × 12 in.
Engine truck wheels, diameter	30½ in.
Engine truck journals	6 × 10 in.
BOILER.	
Style	Wagon Top
Working pressure	190 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	124 × 37¼ in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	5 in.
Tubes, number and outside diameter	355—2 in.
Tubes, length	15 ft.
Heating surface, tubes	2,788 sq. ft.
Heating surface, firebox	206 sq. ft.
Heating surface, total	2,994 sq. ft.
Equivalent grate area	32.1 sq. ft.
TENDER.	
Wheels, diameter	33½ in.
Journals, diameter and length	5½ × 10 in.
Water capacity	7,000 gals.
Oil capacity	2,940 gals.

A NOTE ON COMPOUND LOCOMOTIVES.*

The application of the compound system to the locomotive, although accompanied by an important increase in pressure, and other improvements contributing to ameliorate its working, has not produced generally so great an economy as in the case of stationary, and especially marine, engines, for which the adoption of successive expansions has constituted one of the most considerable transformations that the steam engine has undergone. The simple expansion marine engine practically ceased to exist from the day when compound, and subsequently, triple-expansion engines were introduced on board ships. The simple expansion locomotive, on the contrary, continues to coexist with the compound locomotive.

This state of things has been attributed to two classes of different facts:

(a) The frequency and range of the variations in the work done by the locomotive.

(b) The relatively economical efficiency of non-compound locomotives.

The mode of application to the locomotive, and its complete adaptability to the conditions of the problem, have also been sometimes called in question.

I propose to examine in this note some of the data relating to compound locomotives, and to give alongside of recognized facts some personal opinions. In the first place, it appears to me necessary to recall general elementary and well recognized facts.

* Abstract of an article by M. Maurice De Moulin, chief engineer of the Western Ry. of France, author of "La Locomotive Actuelle," etc., published in *The Engineer* (London), Aug. 23-30, 1907.

Summing up, the compound system comes to this. Instead of admitting steam during a period "a" into a single cylinder volume V, it is admitted during a period "b" $<$ "a" into, first, a high pressure cylinder of volume "v," and then, secondly, during a period of "c" $<$ "b" into a low pressure cylinder of volume W. By neglecting the influence of clearance and drop in pressure, an engine of this description may be regarded as equivalent to one with a single cylinder of the same volume as the low pressure cylinder, in which the ratio of expansion would be the same. This artifice enables the compound engine to develop the same final degree of expansion, with larger admissions, in the ratio W ÷ v. From this property proceed the two principal advantages of the compound method. It allows a large range of expansion to be obtained with ordinary valve gear, without any disorganization of the phases of distribution occurring, such as an excessive increase in lead and of compression, wire-drawing, etc.

It augments the limits of economical expansion by reducing the range of temperature in the cylinders and consequently initial condensation. In addition to these two primordial advantages may be taken into account other causes of economy, or of good working, such as the re-evaporation in the low pressure cylinders of the steam condensed in the high pressure cylinder; the reduction in leaks round the valves and pistons, in consequence of the reduction of the difference in the pressure in each cylinder; the torque is more uniform. In the case of locomotives with four cylinders these advantages are completed by the diminution of fatigue of the parts of the mechanism, thanks to the distribution of the stresses over four cranks, and by the balancing.

The mechanical advantages resulting from the division of the stresses among four cranks are no longer disputed. In fact, both in England and Belgium, four-cylinder non-compound locomotives are in regular service.

The first and last of the causes, quoted above, of the economical working of the compounds, preserve their value under all conditions; the second, relative to the reductions of range in the temperature in each cylinder, becomes less and less important as the velocity of the piston is increased, because of the shorter time allowed for the changes of temperature between the cylinder walls and the steam. It appears certain that for all piston velocities exceeding about 11 ft. per second (28 inch stroke, 72 in. drivers, 30 M. P. H.) it matters but little from a thermodynamic point of view, for range of expansion of six to seven, whether the expansion takes place in one cylinder or in two. On the other hand, when the velocity is very high the first advantage—large expansion—may itself be reduced to a very secondary place, wire-drawing intervening.

So far as the locomotive is concerned, all the working elements—load, inclines, speed—even the force or direction of the wind—undergo to the fullest extent incessant variations. In addition, the locomotive is subjected to a condition which belongs to itself, and the equivalent of which is not to be found

in any other application. It should produce at the moment of starting a maximum tractive force with the minimum of power; and, on the contrary, a maximum amount of horse-power when the tractive force is smaller and the speed high. In other words, contrary to what one observes in fixed and marine engines, the mean effective pressure on the pistons, and consequently the mean value of the torque, are in no respect proportional to the work, and may prove to be, all things equal elsewhere, smaller when the total work is the more considerable.

The proportions of the cylinders can be but a compromise between these contradictory conditions, and the admissions, the range of expansion, the pressure in the valve-chest, undergo variations, very frequent, very important, and irreconcilable with maximum efficiency. We shall be led to observe in the utilization of the steam, variations in relation to those of the work, by which it can be established that for every engine, simple or double expansion, there exists an ascertained initial pressure and a ratio of expansion corresponding to maximum economy. Fatal departures from the economical regime exist, whatever may be the mode of expansion adopted. They may be reduced, but not suppressed, since they are inherent to the method for the production of power.

In any case the efficiency of the steam in the cylinders of the simple expansion locomotive is, all other things equal, proportional to the piston speed, and maximum at high speed, when the effective expansion is a maximum, the injurious influence of the clearance annulled, and the action of the cylinder walls very much reduced. One is led to observe that the wire-drawing, far from being detrimental to the locomotive, is an auxiliary and a corrective of the ordinary valve gear, in the sense that it allows of the realization of a ratio of expansion superior to that which results from single phases of distribution. The only inconvenience which can be attributed to it, the reduction of the mean pressure for a cylinder of given capacity, is without importance, the cylinders of the locomotive, calculated with regard to the effort at starting a train, being too large for normal service.

Considering the normal cycle in the cylinder of a locomotive running at high speed along a fairly level line, one is induced to think that the application of the compound principle would not give any sensible economy, so long as this cycle was maintained. The expansion can reach to seven volumes and clearance is annulled. A compound engine having a ratio of volume of 2.50, and admitting steam to 0.40 per cent. of the high pressure cylinder, would give a nominal expansion of $2.50 \div 0.40 = 6.25$. Considering the high velocity of the pistons, it is not necessary to take into account here the special action of the expansion in the two successive cylinders for reducing internal condensation.

One is therefore justified in asserting that for high-speed locomotives running without stopping over nearly level lines, the compound system, such as it is at present, seems to have yielded but a poor economy.

Under contrary conditions, a compound locomotive, working with frequent starting, switching and siding work and having still a ratio of L. P. to H. P. of 2.50 volumes and working 0.50 of admission, the high pressure range of expansion reduced to 0.45 at the most by wire drawing, would realize an expansion of $2.50 \div 0.45 = 5.5$ volumes instead of 2 to 2.5 volumes, given by the non-compound engine. It will then be more economical, the expansion being greater, and the clearance annulled by compression; besides, the piston speed being less than in the first case considered, the double expansion will involve an expansion of better quality than that of a non-compound engine. It is here that the occasion presents itself for bringing forward an advantage of the compound system which does not appear to have been hitherto sufficiently discussed.

In the non-compound locomotive, the compression is completed only for a determined working, corresponding to a large amount of linking up, and to a piston speed sufficient for the wire-drawing to produce its effect. In the compound engine, the compression is much more complete for all positions of the links, annulling more thoroughly the effect of the clearance.

All existing locomotives are to be classed according to the nature of their service, between the two extreme categories examined above—tractive effort as regular as possible, generally at high speed; tractive effort very irregular and speed variable, and often small. Compounding will have a greater advantage as the conditions approach nearer to the second category, which, I may say, is an opinion opposed to that for a long time previously prevalent. The arguments hitherto put forward allow it to be concluded that compounding presents its greatest advantages for engines when called upon to steam the more frequently with long cut-offs and moderate piston speeds.

On the other hand, it is chiefly in the case of locomotives running at high speed, where the boilers are generally taxed to their maximum of production, that a reduction in the consumption per horse-power is necessary. It may also be accepted that to impart to compounding a superiority under all conditions of working it would be necessary to increase the ratio of the volumes L P to H. P. beyond the proportions frequently adopted, and in all cases not lower than 2.80.

It would be altogether excessive to conclude from what has gone before that the compound type cannot be applied with advantage to high speed locomotives. In fact, these engines work in the ideal condition previously investigated, for a part of the time, and the simple expansion becomes insufficient so soon as these conditions are unfulfilled, and the mean effective cylinder pressure rises above a certain value, especially if the speed falls off in a corresponding proportion. For the starting of trains, the climbing of gradients, and the haulage of heavy trains, the compound system remains at the best for increasing the tractive effort without allowing the consumption of steam to rise in the same proportion. The ratio of minimum expansion should never descend below $\frac{1}{4}$. If the compound system yields little or no economy at high speed especially with light trains on the level, or down grade, it will not the less constitute an important equipment, valuable for running up grade, etc. At such times, the economy that it will offer will probably be from 20 to 25 per cent., and if the total economy after a long run does not rise to more than 10 or 12 per cent., one has to distribute over the whole distance an economy which is only obtained over a fraction of the total distance it represents. If it is objected that this total economy is too small to justify the supplementary complication of the compound engine presumably of four cylinders, it must be kept in mind that the compound system has not so much for its object to obtain an economy in fuel as a reserve of power, an increase of tractive effort, without surpassing the capacity of the boiler, over the difficult portions of the line. Even when the total economy would be nothing, if the system permits, with a given boiler, of achieving a greater speed on inclines, or a higher average rate of speed, or the eventual hauling of heavier trains, without a proportional demand on the boiler, its adoption is still rational.

One is thus led to recognize that the compound locomotives, far from lacking that elasticity for the absence of which they have been reproached—present, on the contrary, an elasticity superior to that of simple expansion locomotives to a degree in which perhaps they find their principal advantage.

Many engineers have remained faithful to the simple expansion locomotive, appreciating above all its simplicity and compactness. However, in proportion as the locomotive approaches the limits of possible power, the interest increases more and more in the use of methods intended to augment its power per unit of weight, or grate area and compounding seems one of the most effective methods of obtaining the required result.

When the piston velocity is small, compounding has a thermic effect, the more pronounced as the cut-offs into each of the cylinders are lengthened. On the other side the theoretical efficiency is proportional to the degree of expansion, and consequently inversely proportional to the value of the high and low pressure admission which proceed from them. The most economical rate of working in practice, results then in a compromise between these contradictory conditions.

In virtue of the two principles recalled to mind at the commencement of this note, early cut-offs are contrary to the compound principle, and it appears that the most advantageous work-

ing corresponds to a high pressure admission, bordering upon 50 per cent., which the wire-drawing reduces to 40 per cent., according to the piston speed and the proportions of the ports. If one is obliged further to restrict the high pressure admission in the compound locomotive, it is because the initial pressure is too high, or the volume of the high pressure cylinders too great.

We consider that it would be good practice with compound locomotives to arrange the reversing gear in such a manner that the links could not be fixed in notches included between the dead point and the notch corresponding to 0.45, or 0.50 high pressure admission, which with the inevitable wire-drawing, agrees with the lowest degree of cut-off which appears practically efficient.

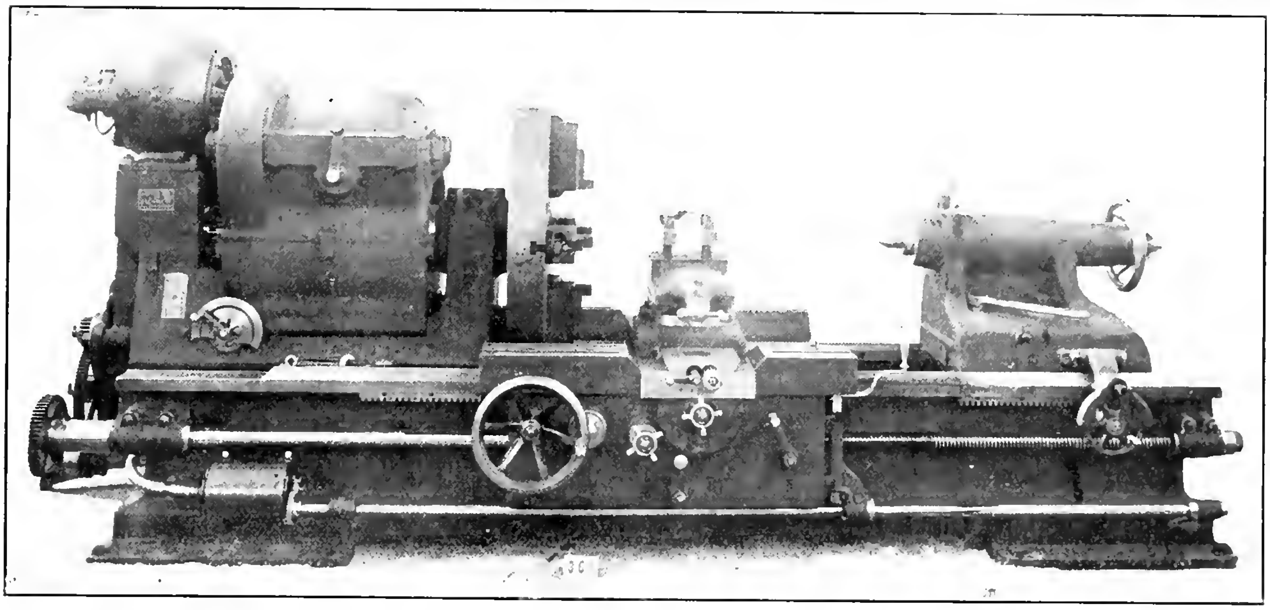
The increase of the minimum high pressure admission, consequently of the low pressure, which are functions, has for consequence the reduction of the initial pressure under certain conditions of working and can even render useful the reduction of the volume of the high pressure cylinders in relation to the proportions adopted at present. There would result from this, on the other hand, the advantage that the relation would find itself increased without augmentation of low pressure volume. The degree of expansion will thus be greater, and the valve gear might become common for the two cylinders of the same group. The only inconvenience would consist in the reduction of the tractive effort at starting, due to the smaller cylinders; but allowing for the steam starting gear with which these engines are furnished, this inconvenience appears to be of secondary importance.

But the advantage of the reduction of the high pressure volume would be especially noted for working with limited power per stroke, with the view of debiting the same volume of steam with longer high pressure cut-off. I think that it will often be found advantageous to reduce the volume of the high pressure cylinders in such a manner that, the low pressure volume not changing from the actually usual proportions, the ratio of volumes would stand between 2.80 and 3.00. Several builders have entered upon this path.

Resuming, this increase of the ratio "w" offers many advantages. It assures a longer expansion at high speed, when the mean pressure should be small; in the case of other working it allows the same degree of expansion to be obtained with longer cut-offs, of which the thermic advantage does not admit of argument; it assures a reduction of the initial stress by securing the least variations in average pressure in each cylinder; and finally it renders possible, practical, and advantageous from every point of view, the employment of only one ordinary valve gear for both high and low pressure, assuring automatically the most advantageous ratio of admission to the two groups, without the intervention of the engine driver, thus preventing all mistakes.

In this order of ideas I would indicate for a compound locomotive having four cylinders, a grate surface of 32.4 to 37.7 sq. ft., and a boiler pressure of 245 lbs., the following proportions:

Diameter of cylinders, H. P.	=	14 in.
" " " L. P.	=	23.6 in.
Stroke	=	26 in.
Ratio of volumes		2.90



SPRINGFIELD 36-INCH MOTOR DRIVEN ENGINE LATHE.

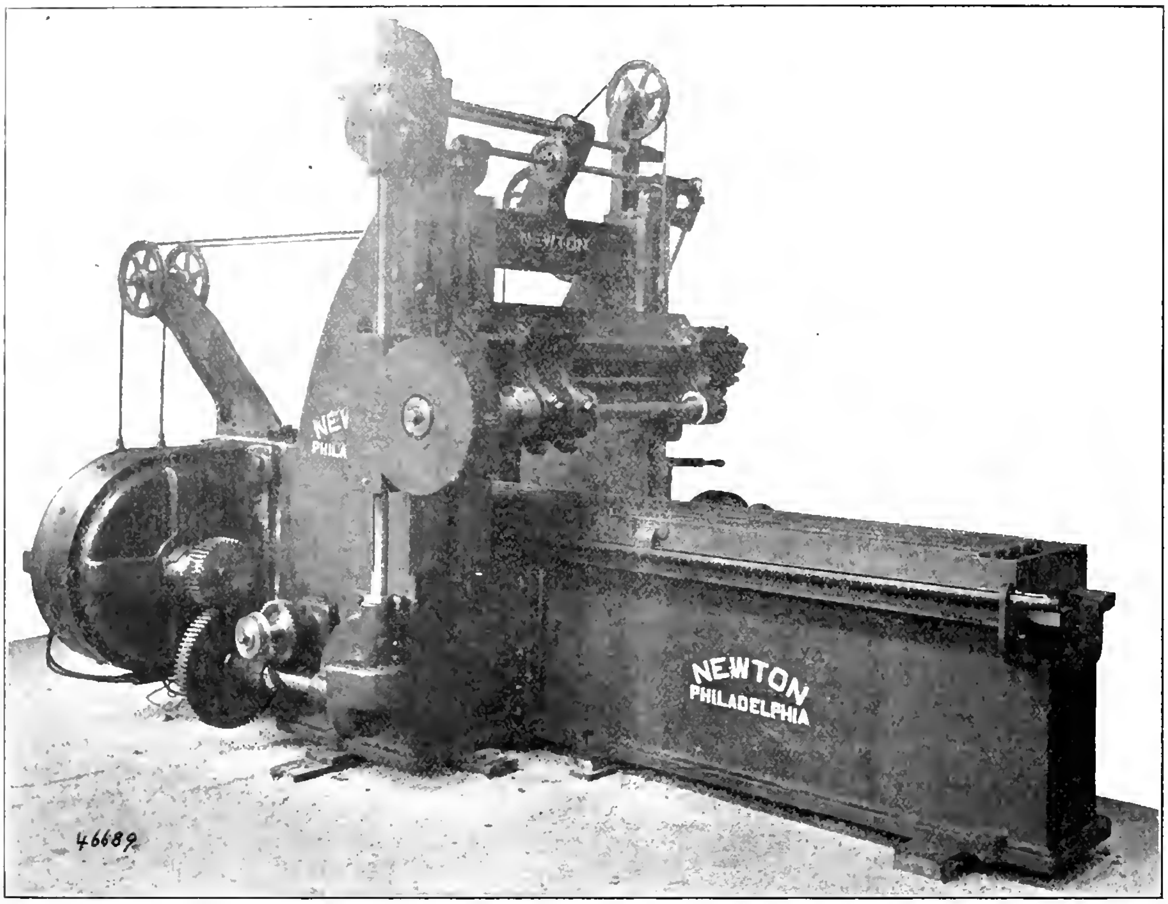
36-INCH MOTOR DRIVEN ENGINE LATHE.

A good example of a compact and efficient motor drive for a large size engine lathe is shown in the accompanwing illustration. Those who are familiar with the standard 36-inch engine lathe made by The Springfield Machine Tool Company, Springfield, Ohio, will at once see that the headstock has been entirely re-designed to take the motor drive, the result being a neat, rigid, compact construction. Any kind of variable speed motor may be used; the one shown has a speed range of from 600 to 1,200 r. p. m., obtained by field control. The power required, of course, depends on the class of work which is to be done, but for average requirements the makers recommend a 10 h.p. motor.

Power is transmitted from a rawhide gear, on the motor shaft, to a large gear keyed on an intermediate shaft just above the lathe spindle. On this shaft are three sliding gears, any one of which may be slid into mesh, by means of the handle on the outside of the casing, with one of three gears on a sleeve on the spindle. This with the back gears makes six different spindle speeds available, which in conjunction with those furnished by the motor provide a wide range with ample power. The motor controller is attached to the side of the bed, near the head end, and is operated by a handle, at the right side of the carriage, through suitable gearing and a splined shaft.

A pair of cone gears, suitably supported at the rear end of the headstock and manipulated by the handle shown on the front side of the headstock, furnishes three sets of ratios for feeds and screw cutting. They may be thrown in or out while the lathe is running. Power feed is furnished for the top slide of the compound rest, as well as for the cross and longitudinal motion of the carriage. All feeds are engaged by means of frictions and reverse motion is controlled at the apron.

The tail stock is clamped to the bed by four large bolts and may be moved back and forth by a handle which, through suitable gears, operates a pinion which engages with the rack, as shown. A taper attachment may be supplied, if desired, which is of an improved type, arranged so that it may be connected or disconnected instantly by loosening one bolt and tightening another, or vice-versa.



NEWTON HORIZONTAL MILLING MACHINE.

HORIZONTAL MILLING MACHINE.

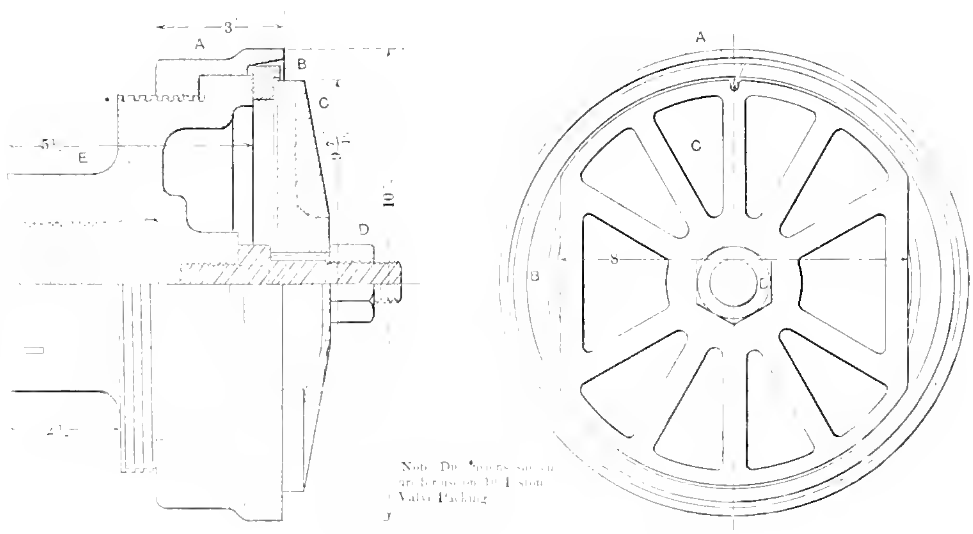
The American Locomotive Company has recently received several small plain horizontal milling machines from the Newton Machine Tool Works, Philadelphia, similar to the one shown in the illustration. The table is 23 in. wide and of sufficient length to mill a piece 14 ft. long. The uprights will admit work 30 in. wide and the center of the spindle can be raised 30 in. above the table. They are driven by 2 to 1 variable speed, 25 h.p., General Electric motors. The spindle is 5 in. in diameter, has a side adjustment of 6 in. and is driven by a phosphor bronze worm wheel and hardened steel worm with a roller thrust bearing, which runs in oil.

The cross rail is of the inclined face design, is counterweighted and has both hand and rapid power motion in both directions. The lifting screws are so designed that they are in tension when drawing the cross rail down, thus eliminating any tendency to buckle. For convenience in working around bosses and oil cups forged on connecting rods, the center of the spindle is carried 2½ in. below the bottom of the rail. The cutter arbor is driven by a face or "butterfly" key and the outboard arbor support is fitted with a taper bushing to compensate for wear.

The table is operated by a spiral pinion and rack, has nine changes of geared feed and is so designed that it is held rigidly in any position to prevent it from working back when sinking into the cutter. The table has a rapid [illegible] motion in both directions and [illegible] which controls this motion [illegible] the rapid power motion of the cross rail, is conveniently placed on the operating side of the machine. The machine weighs about 28,000 lbs. and is practically self-contained, as the motor is bolted rigidly to the uprights. It is specially adapted for the milling of small side rods and similar work of this class, of which there is a large variety in railroad repair shops.

CHUCK FOR VALVE AND PISTON PACKING RINGS.

A chuck for holding snap packing rings, after they have been rough turned and the slot has been milled out, is shown in the accompanying illustration. The advantage of this device lies in the fact that it compresses the ring equally on all sides in clos-

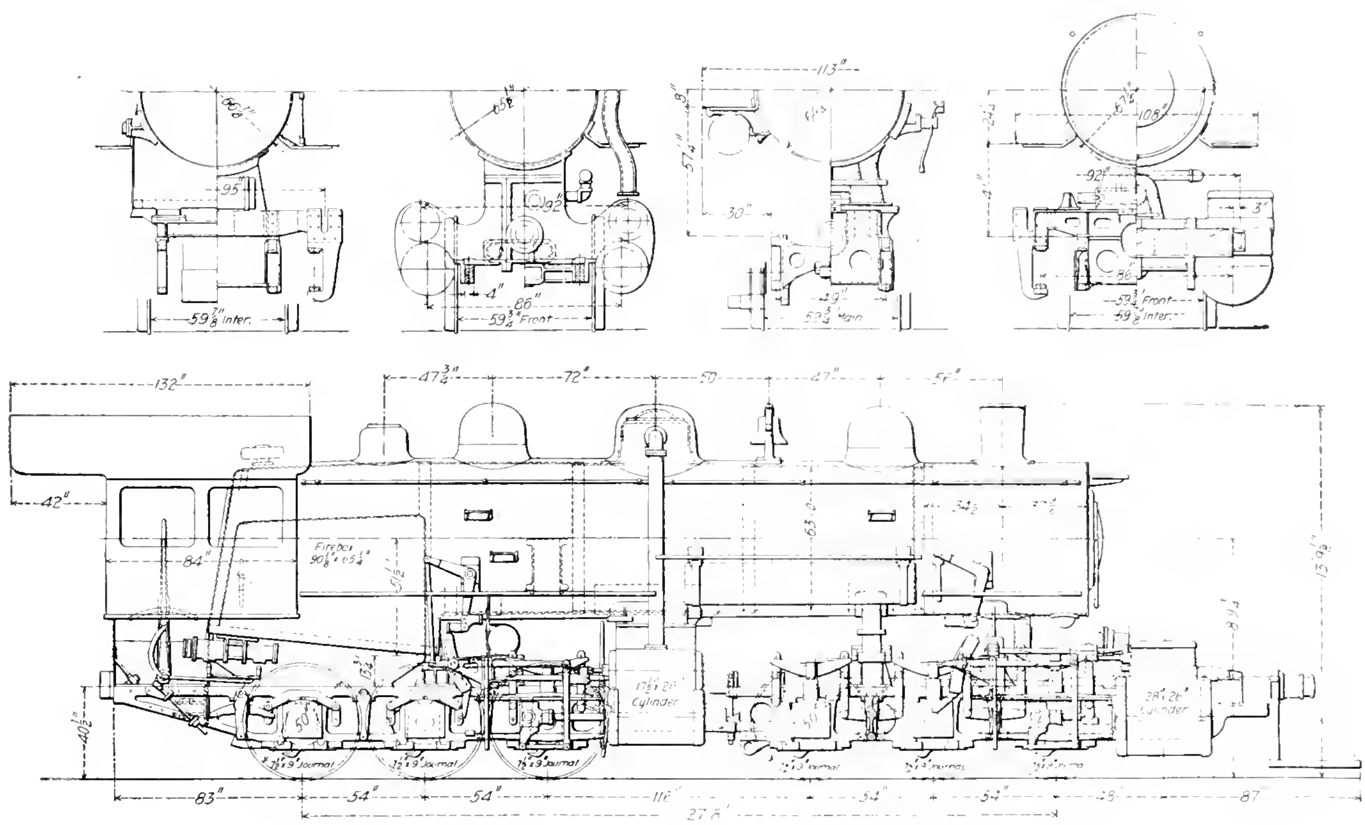


VALVE AND PISTON PACKING RING CHUCK.

ing it up for the finishing cut, so that it will exert an equal pressure on all sides of the valve bushing or cylinder when in place. It also will be of equal section at all points and hence be less liable to breakage.

Using the letters as shown in the illustration, the method of using this chuck is as follows: The packing ring, B, having been previously turned to $\frac{1}{8}$ in. larger than the diameter of the valve chamber or cylinder and a 3/16 in. section having been cut out at an angle of 45 degs. is placed in the chuck, which is in place on the spindle of the lathe, and plate, C, is held lightly against it by nut D. Ring A is then screwed up with a spanner wrench and its inner beveled edge compresses the ring equally on all sides until the slot is closed. The nut D is tightened up and plate C will hold the ring in position. Ring A is then moved back out of the way and the packing is trued up to the correct diameter.

This chuck was designed and has been patented by Mr. John Rusche, general foreman of the Grand Crossing shops of the Chicago, Burlington & Quincy Railway, where it has been in very successful use for several years.



MALLET COMPOUND LOCOMOTIVE FOR ROAD SERVICE, CENTRAL RAILWAY OF BRAZIL.

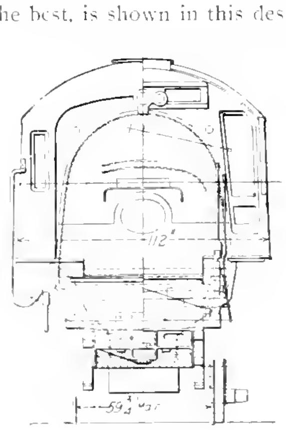
MALLET COMPOUND FREIGHT LOCOMOTIVE.

CENTRAL RAILWAY OF BRAZIL.

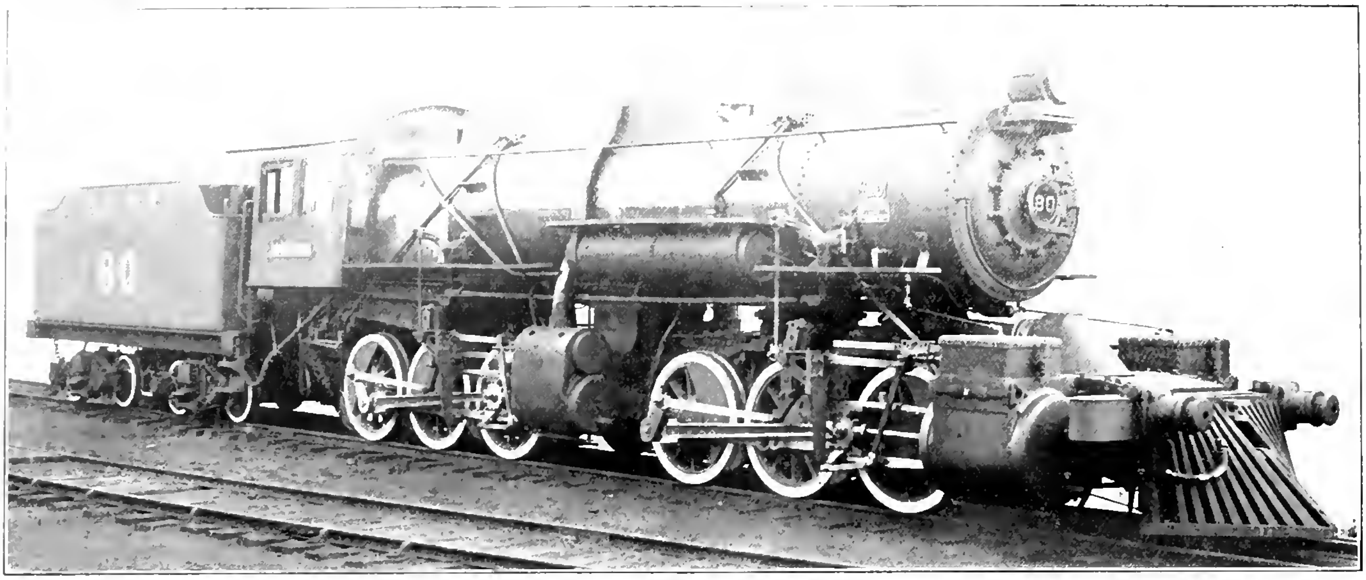
The American Locomotive Company has recently delivered a Mallet compound locomotive to the Central Railway of Brazil, which presents an interesting example for study in connection with a consideration of this type of locomotive for regular road service. This is the lightest Mallet compound ever built by this company and weighs but 206,000 lbs. total, all of which is on the six pairs of drivers.

Comparing this engine with one of the consolidation type, many features of advantage in favor of the Mallet, especially on roads with heavy grades, sharp curves and light road beds, are evident. The design under consideration presents a tractive effort of 42,420 lbs., with an average weight per axle of 34,333 lbs. and a rigid wheel base of 9 ft. Assuming that the axle weight was limited to this figure, the heaviest consolidation which it would be possible to use would weigh but 152,400 lbs. and would deliver a tractive effort of but 28,200 with the same factor of adhesion, while at the same time it would have a longer rigid wheel base. If it was desired to obtain the tractive effort given by this engine in the shape of a consolidation, assuming the same factor of adhesion, such a locomotive would weigh 220,000 lbs. total and would give a weight per axle of 51,500 lbs. A consolidation of the same total weight would give a weight per axle of 46,350 lbs. and deliver a tractive effort of but 38,200 lbs. These figures clearly indicate that under conditions limiting the weight per axle, and especially if the rigid wheel base is also restricted, the Mallet compound offers practically the only opportunity to obtain great power from one machine.

Another feature of advantage, in cases where the facilities for repair are not of the best, is shown in this design by the lightness



of the different parts, as for instance, the main rods, which weigh but 417 lbs., in comparison with 825 lbs. on a heavy consolidation. The same ratio of weights also holds for a number of other parts. The disadvantage of the multiplicity of moving parts and general duplication of the running gear is undoubtedly more



SMALL MALLET COMPOUND LOCOMOTIVE FOR ROAD SERVICE—CENTRAL RAILWAY OF BRAZIL.

than offset by the advantages mentioned above, and it would seem that this type has fully as great a future in connection with light power for road service as it is generally admitted to have for the heavier classes of work.

In general, the design of this locomotive is a small edition of both the Baltimore & Ohio and Erie locomotives built by the same company. It, however, does not contain some of the special features found on the heavier engine, such as a floating balance device, spring centering arrangements, etc.

The general weight, dimensions and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Cardiff Coal
Tractive effort	42,420 lbs.
Weight in working order	206,000 lbs.
Weight on drivers	206,000 lbs.
Weight of engine and tender in working order	304,300 lbs.
Wheel base, rigid	9 ft.
Wheel base, total	27 ft. 8 in.
Wheel base, engine and tender	55 ft. 2¼ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.88
Total weight ÷ tractive effort	4.88
Tractive effort × diam. drivers ÷ heating surface	905.00
Total heating surface ÷ grate area	54.30
Firebox heating surface ÷ total heating surface, per cent	5.25
Weight on drivers ÷ total heating surface	89.00
Total weight ÷ total heating surface	89.00
Volume equivalent simple cylinders, cu. ft.	11.20
Total heating surface ÷ vol. cylinders	207.00
Grate area ÷ vol. cylinders	3.66

CYLINDERS.

Kind	Mellin Comp.
Diameter and stroke	17½ and 28 × 26 in.

VALVES.

Kind	H. P. Piston, L. P. Slide
Greatest travel	H. P. 5 in., L. P. 5½ in.
Outside lap	⅞ in.
Inside clearance	3/16 in.
Lead in full gear	3/16 in.

WHEELS.

Driving, diameter over tires	50 in.
Driving, thickness of tires	3 in.
Driving journals, diameter and length	7½ × 9 in.

BOILER.

Style	Straight
Working pressure	[illegible] lbs.
Outside diameter of first ring	64¼ in.
Firebox, length and width	[illegible] × 65¼ in.
Firebox plates, thickness	[illegible] and ½ in.
Firebox, water space	F. 5, S. and B. 4 in.
Tubes, number and outside diameter	234—2 in.
Tubes, length	18 ft.
Heating surface, tubes	2195.2 sq. ft.
Heating surface, firebox	121.5 sq. ft.
Heating surface, total	2316.7 sq. ft.
Grate area	41 sq. ft.
Smokestack, diameter	16 and 19 in.
Smokestack, height above rail	13 ft. 9½ in.

TENDER.

Tank	Water Bottom
Frame	10 in. Channels
Wheels, kind	Rolled Steel
Wheels, diameter	30 in.
Journals, diameter and length	5 × 9 in.
Water capacity	4,500 gals.
Coal capacity	8½ tons

STOCKHOLDERS OF THE PENNSYLVANIA RAILROAD.—Some very interesting figures have been obtained by the compilation of the holdings of the Pennsylvania Railroad Company's stock on October 1, 1907. The capital stock of the company on that date was $312,061,900 divided into 6,241,238 shares. These shares are held by 49,572 persons, making the average holding of each at 126 shares. Of the total number of shareholders 46.92 per cent. were women. 19.27 per cent. of the entire capital stock of the company is held abroad. The average holdings of the 8,526 stockholders in foreign countries being 141 shares each. At the present rate of increase it is stated to be likely that when the books were closed on November 5, for the payment of the semi-annual dividend, the stockholders of the company would number more than 50,000.

LONG NON-STOP RUN.—The Great Western Railway of England on September 16 ran a special train from London to Fishguard, a distance of over 263 miles, without a stop. The train returned on the second day following, also without a stop. The outbound trip was made in a total of 298 minutes, or at an average speed of 53 miles per hour; the return trip was made at an average speed of 53½ miles per hour. The train consisted of four 70 ft. passenger cars and a 73 ft. dining car, and was drawn by a 4-4-0 type engine.

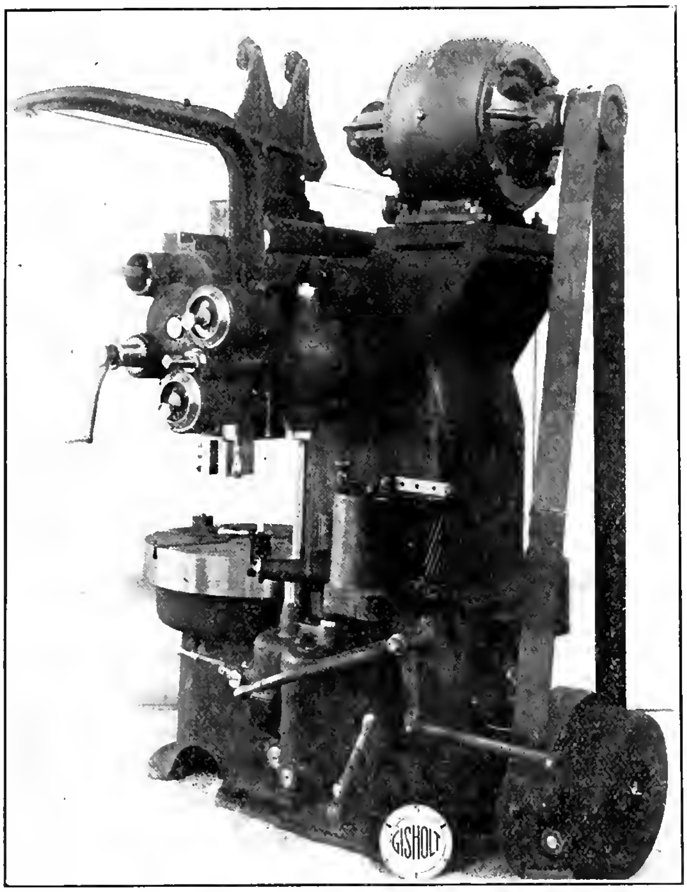
AUXILIARY EXHAUST TO EQUALIZE DRAFT.—A conclusive test of the auxiliary exhaust is advisable because, with the modern large power with its high steam pressure and great volume of exhaust, light and economical firing is practically impossible without some method of equalizing the draft through the firebox and softening the exhaust when working at full stroke and under heavy throttle.—*Report of Committee, Traveling Engineers' Association.*

NO SAVING IN FUEL BY ELECTRIFICATION.—Viewed in the light of greatest benefits to be secured, the coming of the electric locomotive is not due to petty economies effected in coal consumption and cost of locomotive repairs; indeed, with coal as a common source of power, little gain in efficiency is secured through burning the same grade of fuel under stationary boilers over the excellent results obtained with the highly perfected modern compound locomotive.—*Mr. A. H. Armstrong before the Amer. Inst. Elect. Engineers.*

NEW TESTING LABORATORY.—What is said to be one of the most complete railroad testing laboratories in this country has been completed at the new Omaha shops of the Union Pacific Railroad Company. This laboratory occupies part of the new shop office building and includes complete equipment for both physical and chemical tests of all kinds, as well as bacteriological investigations, photographic work, electrical experiments, metallurgy, etc.

MOTOR DRIVEN BORING AND TURNING MILL.

An interesting application of a variable speed motor drive to a Gisholt boring and turning mill is illustrated herewith. The 5 h.p. motor has a 4 to 1 speed range (400 to 1,000 r. p. m.). The three-step cone pulley used on the belt driven machine is replaced by a single friction pulley which is controlled by the long lever shown in the illustration. The table is thus under absolute control of the operator and may be started, stopped, or moved any part of a revolution at will. The motor is carried



GISHOLT MOTOR DRIVEN BORING AND TURNING MILL.

on a substantial bracket and the controller is attached to the frame of the machine.

The machine may be furnished with either a plain table or chuck and has an extreme swing of 36½ in. It is provided with eight gear driven feeds and with a friction device to guard against stripping the gears through careless handling. All feed screws are fitted with micrometer index dials reading to .001 in.; the tool in the turret may be moved .001 in. or more in any direction without the use of a scale. A feed tripping device makes it possible to automatically throw off the feed at any predetermined point; it will also positively trip any feed at either end of the feed traverse whether the dials are set or not.

Standardizing Grades of Coal.—It is recommended that an effort be made to bring about the standardizing of grades of coal furnished for locomotives. That the desirability of better grades of coal, both in the line of economy and convenience, is unquestionable, but if managements cannot be brought to realize the economy of good coal, or, if it is impossible to obtain it at all times, efforts should be made to insure the furnishing of one particular grade at all times, in place of from half a dozen to 20 different varieties. No mechanic on earth could turn out satisfactory work if you changed the style and pattern of his tools daily, and it is just as impossible for the fireman to do himself justice or work for the best interests of his employers if a continual change is being made in the kind of fuel he must use.—*Report of Committee, Traveling Engineers' Association.*

A RECORD IRON PRODUCTION.

The Refined Iron and Steel Company of Pittsburg, in the month of August, made what is said to be a record production of muck bar, considering the number of furnaces in operation. The output for that month was 1,198 tons from seven double puddling furnaces. The average number of furnaces in use during the month was six per day and the greatest production of any one day of twenty-four hours was 83½ tons.

The furnaces in use in this mill were especially designed according to the ideas of Mr. William Stubblebine, general manager of the company, who expected the maximum capacity of the seven furnaces would be 70 tons a day, and a record of 83½ tons is thus particularly gratifying.

It might be added that there is a prospect of this record being exceeded because of the fact that four single heats were lost because of the shortage of raw material and a few turns on account of excessive heat.

This company is giving the matter of the quality of its iron even closer consideration than quantity records. That it is being equally successful in this respect is shown by the figures in the following tables, which give the results of careful tests made by disinterested parties on three different grades of iron. The different grades of iron were obtained by different methods of piling and heat treatment.

Not being satisfied to rest on its laurels, however, the company is continually increasing the capacity of its plant, and has recently finished some mills which will enable it to produce bar iron from puddled muck bar which will be put on the market in competition with common bar iron.

Specimen.	Diameter, in.	Length, in.	Tensile Strength, lbs. per sq. in.	Elastic Limit, lbs. per sq. in.	Per Cent. Elongation.	Per Cent. Contraction of Area.
STAY BOLT IRON.						
1 in. rd.	1.005	8	49,130	31,610	30.00	48.7
⅞ in. rd.	.887	8	49,540	34,860	30.25	49.6
1 in. rd.	1.000	8	49,560	33,020	29.75	47.4
⅞ in. rd.	.890	8	50,160	34,370	27.75	47.5
1 in. rd.	1.005	8	49,790	33,720	29.25	46.5
⅞ in. rd.	.890	8	50,910	36,380	29.75	40.1
DOUBLE REFINED IRON.						
⅞ in. rd.	.878	8	51,930	37,850	25.5	37.2
1 in. rd.	1.003	8	50,570	33,910	28.25	35.1
1¼ in. rd.	1.255	8	50,410	32,150	26.25	40.7
SPECIAL ENGINE BOLT IRON.						
1 in. rd.	1.005	8	55,500	38,040	26.25	43.6
1 in. rd.	1.007	8	55,270	38,050	27.50	46.0
1 in. rd.	1.010	8	54,470	36,170	27.50	46.3
1 in. rd.	1.010	8	54,890	37,620	28.75	46.3

Car Ferry on Lake Ontario.—The Buffalo, Rochester & Pittsburg Railway and the Grand Trunk Railway have established a car ferry across Lake Ontario between Rochester, N. Y., and Coburg, Ont. The first boat for this service has recently been put into operation and is the largest ever operated on Lake Ontario, being 317 ft. in length, and 57 ft. 7 in. beam. It has a capacity for 26 freight cars and is sufficiently powerful to operate throughout the winter season. In addition to carrying freight cars it is also designed for the accommodation of passengers. Two round trips will be made in each 24 hours.

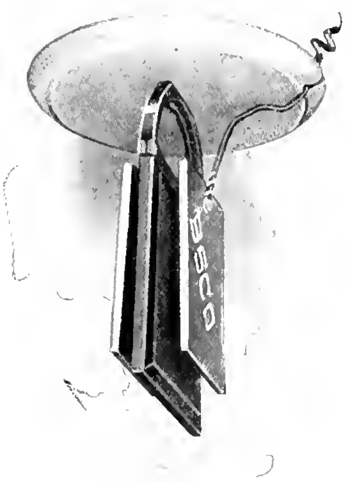
Engineering Library Open Evenings.—The reference libraries in the United Engineering Societies Building, New York, are opened on all week days, except holidays, until nine o'clock in the evening. These libraries are available to the members of the Associated Societies and to the public generally subject to the proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies. This building is located at 29 W. 39th street, New York City.

Electrification of Mountain Grade Divisions.—There are other items of saving and other reasons for electrification which may be more or less controlling in individual cases, but it seems possible to make the broad statement that the mountain-grade division offers a particularly attractive field for the electric locomotive, and its introduction should be the means of affecting such economies in both freight and passenger transportation as to pay a satisfactory return upon the investment required.—*Mr. A. H. Armstrong before the Amer. Inst. Elect. Engineers.*

A NEW PRIMARY BATTERY.

A new type of battery, which is of unusually substantial construction, and conveniently arranged for renewal, has recently been developed, primarily for automatic signal purposes. It is, however, also adaptable to other fields where a first-class primary battery is desired.

This battery is of the caustic soda or copper oxide type and consists of a porcelain jar with a porcelain cover to which is fastened a supporting frame or hanger holding the zinc and copper oxide plates. The supporting hanger is secured to the cover by a single large, wing nut on the top and the removal of this permits all of the elements of the battery to be released and a new set inserted in their place. The hanger of channel section is formed in a U shape and carries the copper oxide plate between its extending arms. This plate is securely fastened to the hanger and the two zinc plates are hung one on either side from a porcelain insulator, which passes through and is supported by a cross bar at the top of the copper plate. There is but one piece of wire in the battery, that being securely fastened to the zinc plate



and passing through a slot in the porcelain cover. The other connection is made to the extension of the bolt holding the supporting hanger.

The advantages derived from this method of arranging and fastening the elements are, that it is possible to place the plates much closer to each other than usual without danger of short circuiting, thereby greatly reducing the internal resistance and thus increasing the capacity of the cells. There is also no danger of the plates coming into contact since in renewing the battery the hanger with both sets of plates is thrown away and a complete new set, already rigidly fastened together, is inserted. The zincs in this type of battery are completely immersed and hence the danger of their being eaten off at the surface of the solution is eliminated.

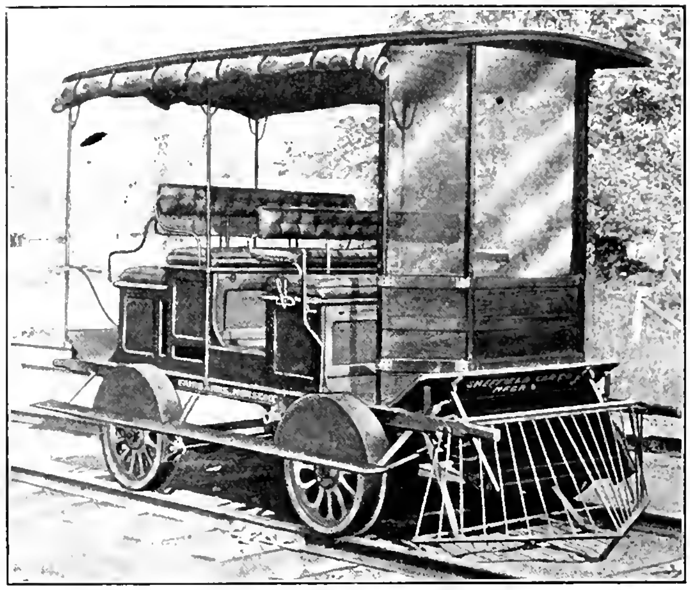
The model of this battery designed for signal work has a capacity of 350 ampere hours and the mean working voltage of .7. The voltage for open circuit is .95. This battery, which is called the "Bsco," is manufactured by the Battery Supplies Company of Newark, N. J.

THE MAGNITUDE OF THE BALDWIN LOCOMOTIVE WORKS.—The report of the committee on science and arts, given in the *Journal* of the Franklin Institute for October, contains some interesting figures on the size of the Baldwin Locomotive Works, some of which are shown in the following table:

Number of men employed	19,000
Number of buildings comprised in the works	47
Horse power employed, steam engines	12,138
Horse power employed, oil engines	4,850
Acreage of floor space comprised in the buildings	6.32
Aggregate h. p. of electric motors	14,200
Number of electric motors	1,115
Consumption of coal, tons per week	3,000
Consumption of iron, tons per week	5,000
Consumption of other material, tons per week	1,460

GASOLINE MOTOR CAR FOR RAILWAYS.

It is now generally admitted that the most satisfactory method of making railway inspection of any nature is by means of a gasoline motor car, and Fairbanks, Morse & Company recognizing this fact are making a specialty of this class of equipment. A number of different designs for special purposes and of varying carrying capacities and weights are being manufactured. The car illustrated has a seating capacity for nine people and is equipped with a top, glass front, and side curtains, making it



GASOLINE MOTOR CAR FOR INSPECTION SERVICE.

available for use in any kind of weather. These cars are capable of very high speeds, at the same time having a wide range in speed and can be operated as slowly as desired for the most careful inspection of track.

The results obtained from a trip by the chief engineer of the Michigan Central Railway indicate the efficiency and speed of these cars. This trip, which covered a total of 2,327 miles, showed an average of 19 miles per gallon of gasoline; 97 miles per battery cell and 517 miles per gallon of lubricating oil. At one part of the trip 39.6 miles were made in 45 minutes, giving a rate of nearly 53 miles per hour; at another point 66.4 miles were covered at a rate of 40 miles per hour.
efits.

LARGEST STACK IN THE WORLD.—The Boston & Montana Consolidated Copper & Silver Mining Co. is building a stack at Great Falls, Montana, which will be 506 ft. high and have an internal diameter of 50 ft. The first 23 ft. is octagonal in shape, built of concrete, the remainder being constructed of hollow fire brick. It is said that the pressure on the foundation will be 5 tons per square foot.

PNEUMATIC FIRE DOOR CLOSER.—A wider investigation of the pneumatic firebox door closer and the mechanical stoker should be made, because the steady increase in the size of power will in all probability necessitate the adoption of some such devices in the interests of economy and of the firemen.—*Report of Committee, Traveling Engineers' Association.*

STEAM TURBINES IN AMERICA.—Although it has been less than a decade since the first steam turbine was operated in this country it is stated that there are to-day about 700 in use, aggregating about 1½ million horse power.

Of the seventeen million dollars paid out by the relief department of the Pennsylvania Railroad since 1886 ten million was paid on account of disablements and seven million in death benefits.

ELECTRIC SWITCHING LOCOMOTIVE.

Large manufacturing plants having a number of buildings covering considerable area have found it necessary to build and equip switching railroads within their own confines. Where electric power is convenient and cheap, or for reasons of cleanliness, noise, etc., it has often been found advisable to electrically equip these roads using small electric locomotives for handling trains of either narrow or full gauge cars.

The Cerveceria Cuauhtence Brewery of Monterey, Mexico, is a plant of this kind, and the 25-ton electric switching locomotive shown in the accompanying illustration has been purchased

ELECTRIC SWITCHING LOCOMOTIVE.

of the Jeffrey Mfg. Co., of Columbus, O., and put into operation at that point. The switching locomotives built by this company are of the same general type and take the same electrical equipment as its well-known electric mine locomotives. The only changes made in the illustrated case are in the side and end frames and the addition of the platform and a suitable cab. This locomotive has two motors of the water-proof type, with drum wound armature and laminated pole pieces.

Locomotives for this service are being built in sizes from 10 to 30 tons, with two motors, and in larger sizes with 3 and 4 motors. These are arranged with rigid frames or with double trucks having a flexible wheel base, as conditions may requre.

Testing Side Thrusts on Rails.—The Pennsylvania Railroad has equipped a section of track, about 166 ft. in length, with rails and cast steel ties of special design, which permit the rail to have a slight movement over the tie, it being maintained in line by an instrument which will register the force with which the flanges of the wheels strike against the rail. In connection with these tests both steam and electric locomotives, as well as various types of cars, are operated at various speeds over this section of the track and it is expected that the final results will give accurate information concerning the side thrusts on the rails, and incidentally on the flanges of the wheels. These tests have brought out the erroneous report in many newspapers that the Pennsylvania Railroad was making a comparative speed test of steam and electric locomotives. While both types may be operated at their maximum speeds at some time during the tests no attempt is being made to compare the speed qualities of the two types.

New York Railroad Club.—At the last annual meeting of this club the following officers were elected for the ensuing year: President, H. H. Vreeland; vice-president, J. F. Deems; 2nd vice-president, W. G. Besler; 3rd vice-president, H. S. Hayward; treasurer, R. M. Dixon, and a new member of the executive committee, George W. West.

PERSONALS

Mr. James Carr has been appointed master mechanic of the Midland Valley R. R., with office at Muskogee, Ind. T., succeeding Mr. C. H. Welch.

Mr. M. M. Dooley has been appointed master mechanic of the Alabama Great Southern R. R. at Birmingham, Ala., succeeding Mr. J. W. Evans, promoted.

Mr. H. R. Knight has been appointed master mechanic of the Western Maryland Ry., with headquarters at Elkins, W. Va., vice Mr. R. C. Evans, promoted.

Mr. J. N. Wilber, master mechanic of the Chicago, Burlington & Quincy Ry. shops at Hannibal, Mo., has resigned, having completed 50 years' service with this company.

Mr. W. Gell has been appointed master mechanic of the Ottawa division of the Grand Trunk Ry., with headquarters at Ottawa, Ont., in place of Mr. Donnelley.

Mr. J. R. Donnelley has been appointed master mechanic of the Northern division of the Grand Trunk Ry., with headquarters at Allandale, Ont., vice Mr. Markey.

Mr. J. F. Graham, superintendent of motive power of the Oregon Railroad & Navigation Co., has had his authority extended to include the Corvallis & Eastern R. R.

Mr. E. A. Wescott has been appointed superintendent of the car department of the Erie Railroad, with headquarters at Meadville. The position of Asst. Mech. Supt. has been abolished.

Mr. D. W. Cunningham has resigned as master mechanic of the Chicago, Rock Island & Pacific Ry. at Valley Junction, Ia., to enter the service of the Missouri Pacific Ry.

Mr. E. H. Smith, heretofore traveling engineer for the Boston & Albany R. R., has been appointed division master mechanic at Allston, Mass., succeeding Mr. A. J. Fries.

Mr. J. W. Evans, master mechanic of the Alabama Great Southern R. R. at Birmingham, Ala., has been appointed division superintendent at the same point.

Mr. Axel Johnson has been appointed general foreman of the car department of the Lake Shore & Michigan Southern Ry. at Collinwood, O., succeeding Mr. J. W. Senger.

Mr. W. H. Hufmann, master mechanic of the Chicago & Northwestern Ry. at Baraboo, Wis., has retired, having completed 50 years in the service of that company.

Mr. J. Markey has been appointed master mechanic of the Middle division of the Grand Trunk Ry., with headquarters at Toronto, Ont., in place of Mr. W. Kennedy, resigned.

Mr. W. I. Rowland, general foreman of the Baltimore & Ohio R. R. at Grafton, W. Va., has been promoted to division master mechanic at the same place to succeed Mr. O. J. Kelly, resigned.

Mr. W. B. McDermott, master mechanic of the St. Louis, Iron Mountain & Southern Ry. at Texarkana, has been appointed master mechanic of the St. Louis Southwestern Ry. at the same point.

Mr. C. F. Ludington has been appointed chief fuel supervisor of the Atchison, Topeka & Santa Fe Ry., with headquarters at Topeka, Kan.

Mr. J. J. Reid has been appointed master mechanic of the Missouri Pacific Ry. at Fort Scott, Kan., in place of Mr. R. G. Long, resigned.

Mr. E. I. Dodds has been appointed assistant superintendent of the car department of the Erie Railroad, with headquarters at Meadville, and the position of Asst. to Mech. Supt. has been abolished.

Mr. C. C. Barclay has resigned as district superintendent of the Pullman Company at St. Paul, Minn., to become connected with the mechanical department of the Northern Pacific Ry. at Livingston, Mont.

Mr. T. Tracy has been appointed assistant superintendent of the car department of the Erie Railroad, with headquarters at Meadville, and the position of Asst. M. C. B. has been abolished.

Mr. Albert Bowman, master car builder of the Cairo division of the Cleveland, Cincinnati, Chicago & St. Louis R. R., has resigned to accept a similar position with the Toledo & Northwestern R. R.

Mr. Frank Cain, master mechanic of the St. Louis Southwestern Ry. at Texarkana, Tex., has resigned to become assistant general master mechanic of the Houston & Texas Central Ry. at Houston, Texas.

Mr. J. W. Senger has been appointed supervisor of materials of the Lake Shore & Michigan Southern, Lake Erie & Western and Lake Erie, Alliance & Wheeling Railways, with headquarters at Collinwood, Ohio.

Mr. William H. Lungren, foreman of car shops of the Philadelphia, Baltimore & Washington R. R. at Wilmington, Del., having been for 54 years in the service of the Pennsylvania Railroad, has been retired under the pension rules.

Mr. A. L. Moler has been appointed master mechanic at Beaumont, Texas, of the Orange & Northwestern R. R., the Colorado Southern, New Orleans & Pacific and the Beaumont, Sour Lake & Western Railways. He takes the place of Mr. J. A. Baker, resigned.

Mr. A. J. Fries, master mechanic of the Boston division of the Boston & Albany R. R., with office at Allston, Mass., has been appointed master mechanic of the Albany division, with office at Springfield, Mass., succeeding Mr. P. T. Lonergan, resigned.

Mr. William Kennedy, master mechanic of the Grand Trunk Ry. at Toronto, Ont., has been appointed superintendent of motive power of the Central Vermont R. R., with office at St. Albans, Vt. Mr. Kennedy succeeds Mr. Archibald Buchanan, Jr., resigned.

Mr. R. L. Doolittle, asst. master mechanic of the Central of Georgia R. R. at Macon, Ga., has been appointed master mechanic of the Atlanta, Birmingham & Atlantic R. R. at Fitzgerald, Ga. The position of superintendent of motive power of this road has been abolished.

BOOKS

Strength of Structural Timber. By W. Kendrick Hatt. Pamphlet; 6 x 9; 39 pages. Published by the Forestry Service, U. S. Department of Agriculture, Washington, D. C. Free on application.

This is the second progress report on this subject and gives the results of tests made by the Forestry Service to show the strength and stiffness of different timbers. There is much of interest and value to the user of structural timber in these results.

Pumps; Notes on the Construction and Working. By Edward C. R. Marks; 5 x 7½; cloth; 259 pages; illustrated. Published by D. Van Nostrand Co., 23 Murray St., New York. Price $1.50.

This is the second and enlarged edition of this work, which covers the latest developments in all classes of pumps, particularly those of the centrifugal type for high lift service, which have made the greatest advance during the last few years. As is indicated by the size of the book, the subject is very completely covered in a clear cut, simple style and includes very little of a theoretical or mathematical nature. In addition to the pumps proper there is much valuable information given in connection with the arrangement of pipes and connections, sizes of pipes, etc., as well as a brief history of the development from the primitive designs. The sectional and line illustrations make the subject matter exceptionally clear.

Modern Steam Traps, Their Construction and Working. By Gordon Stewart; 5 x 7½; cloth; 104 pages; illustrated. Published by D. Van Nostrand Co., 23 Murray St., New York. Price $1.25.

This book does not profess to deal exhaustively with the subject, but is, so far as we know, the first work published dealing exclusively with steam traps. It covers the points which are most vital to the proper and efficient working of such apparatus and illustrates and describes the construction of practically every design of steam trap used in America or England. The book is divided into nine chapters, each of which considers a different general type of steam trap. The illustrations are in the form of sectional views or line drawings clearly showing the interior construction and the operation of the different traps, while the accompanying type matter simply and clearly explains its operation and points out the conditions for which different types are specially adapted. A very complete index is included, adding materially to the value of the book.

How to Use Water Power. By Herbert Chatley; 5 x 7½; cloth; 92 pages. Published by D. Van Nostrand Co., 23 Murray St., New York. Price $1.00.

This book is not advanced as an exhaustive treatise on the subject, but it is intended for the use of young and inexperienced engineers and gives a clear account of the methods and principles of hydraulic engineering, as at present practiced, in a form that can be easily grasped by the workman or student with a limited knowledge of mechanics and mathematics. The keynote of the work is simplicity and utility. The first chapter deals with the sources of power and explains the methods of figuring the amount of energy to be obtained under different conditions. The second chapter is on transmission and losses of power and gives data for computing the loss in any case. Following this are chapters on the hydraulic press, its application; water wheels; turbines; pumps; hydraulic engines; tidal power; water supply; sewerage disposal and dams, all of which are well illustrated and clearly explained.

Mechanical Drawing. By Ervin Kenison. 6¾ x 9¾; cloth; 138 pages; illustrated. Published by the American School of Correspondence, Chicago, Ill. Price $1.00.

This work is designed not so much as a manual for the teacher of drawing as a means of self-help and self-instruction for the student. It forms one of a series of hand-books on allied subjects which lay special stress on the practical side of each subject. The book is divided into four parts, the first one of which illustrates and describes the construction and application, as well as the method of using, the different drawing instruments and appliances; gives examples of lettering, dimensioning, etc., and is followed by problems with explanations of their solution, which will give the student a proficiency in the handling of all the different instruments. The second chapter considers the geometrical definitions, giving examples and problems on each part, and is followed by a chapter on geometrical problems covering all of the simpler and generally used problems of this

kind. The last chapter considers projections, including shade lines, intersections, etc. This book will be found to be of special value as a supplement to a course in mechanical drawing.

Principles of Reinforced Concrete Construction. By F. E. Turneaure and E. R. Maurer. 6 x 9; cloth; 316 pages; illustrated. Published by John Wiley & Sons, 43 E. 19th St., New York. Price $3.00.

This work covers, in a systematic manner, those principles of mechanics underlying the design of reinforced concrete and presents the results of all available tests that may aid in establishing co-efficients and working stresses and gives such illustrations from actual designs as may be needed to make clear the principles involved. It is essentially divided into two parts, the first six chapters treating of the theory of the subject and results of experiments and the remaining four of the use of reinforced concrete in various forms of structures. In the introductory it is stated that the invention of reinforced concrete should be credited to Joseph Monier, who, in 1861, constructed tubs and tanks of concrete surrounding a framework or skeleton of wire. Following this is an historical sketch of the development, uses and advantages of this material for different purposes. The work is profusely illustrated and condenses into either tabular or curved form all of the vital information needed by a designer of reinforced concrete structures.

Machine Shop Work. By Fred W. Turner. Cloth; 6¾ x 9¾; 190 pages; illustrated. Published by the American School of Correspondence, Chicago, Ill. Price $1.50.

This is another work of the same series as the work on mechanical drawing mentioned above, and is stated to be a manual of approved methods in modern shop practice, including the construction and use of the latest types of improved tools and machines and other details of modern shop equipment and operation. The author is an instructor of machine shop work in the Mechanics Arts High School, Boston, Mass., and has arranged the book in four parts. The first section deals with tools operated by hand, such as hammers, chisels, measuring instruments, files, drills, etc., and gives illustrations of construction of each tool, together with the proper method of using it. The second part deals with the lathe and devotes 52 pages to instructions and explanations of the proper procedure for doing different classes of lathe work, being profusely illustrated with line drawings and half-tones and including instructions in proper design and grinding of tools. The third part is on drill presses and planing machines, which are treated in a similar manner, as is also the fourth part on milling and grinding machines. This book will prove to be of great assistance to an apprentice in a shop where a regular shop instructor is not provided, as well as an adjunct to such instructor under other conditions.

A Treatise on Hydraulics. By Prof. Wm. C. Unwin. 6 x 9; cloth; 327 pages; illustrated. Published by Adam and Charles Black, London. (Macmillan Co., 64 Fifth Ave., New York, Agents.) Price $4.25.

The reputation of the author's previous works on this and allied subjects is a sufficient indication of the value of this treatise to any one familiar with them. A casual examination indicates that the same exact and accurate treatment found in the previous books has been followed in this case. As is pointed out in the preface, there now exists an enormous mass of experimental data relating to hydraulic problems which has been accumulating during a period extending over two centuries, and which is of very varying trustworthiness and importance. For a decision on questions which arise in many branches of professional work it is necessary that the engineer should realize the limitation of the formulas given and be acquainted with the degree of confidence which can be placed in them. While this book does not attempt to completely cover all of this field, it gives in every case full reference to the primary sources of information and confines itself to the proper application of the results. The problems concerning the flow of incompressible fluids are accompanied by similar problems concerned with compressible fluids such as air, steam, gases, etc. The arrangement of the work is in the form of a text book, carefully explaining by means of diagrams each of the principles and giving a number of practical examples or problems in connection with each chapter. The chapter on statics and dynamics of compressible fluids gives the principles and their application for the flow of air through orifices, in pipes, through valves, etc. The application for steam and other gases is also included.

The Use of the National Forests. Bound in cloth. 5 x 7 in.; 42 pages. Illustrated. Published by the Forest Service, U. S. Department of Agriculture, Washington, D. C. Free upon request.

There are now about 145 million acres of national forests in the U. S. and about 5 million acres more in Alaska and Porto Rico. Many people do not know what national forests are, and others who have heard about them have little idea of their true purpose and use. The national forests very closely concern all of the people of the country, especially those in the West, and affect directly or indirectly many great business interests. The object of this publication is to explain just what they mean, what they are for and how to use them. It takes up the subject of the causes leading to the establishment of forest reserves, the first of which was authorized in 1891, and proceeds to explain the early mistakes made in establishing boundaries, which lead to considerable criticism of the movement; it shows how these mistakes have been corrected; explains the value of the national forests to the home seeker, who can settle in a national forest if he so desires; to the prospector and miner, who are absolutely free to travel about and explore such forests and work claims in them the same as he would on a public domain; to the users of timber, who can obtain as much or as little timber as may be desired from the national government; to the user of the range, who is allowed to graze his cattle in the national forests and to the public in general, which is greatly benefited in many indirect ways. A number of most interesting illustrations are included, showing how valuable timber lands have been absolutely destroyed for any purpose, by private lumber corporations and also how by wise timbering methods forests can be carefully cut and will continue to be productive. Instructions are also included in this book for the procedure to be followed for obtaining rights for settling, mining, timber, etc., and tables showing the exact location, together with their area, of all of the national forests now controlled by the government are appended.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Milling Cutters.—Catalogs "A" and "B" from the Harrison & Knight Mfg. Company, Newark, N. J., describe a large variety of high speed milling cutters made by them. These include both the solid and inserted tooth types.

One-Lock Adjustable Reamer.—An illustrated description, as well as a price list of these, is presented in a pamphlet received from the Wm. J. Smith Company, New Haven, Conn. They are said to be easy of adjustment and a comparatively low maintenance cost is claimed.

Induction Motors.—The Barrett Electric Mfg. Co., Cincinnati, O., is issuing bulletin No. 106, describing its type of induction motors, which are made in all sizes from ½ to 50 H. P. and for two or three phase circuits. These machines are claimed to be practically fool proof, and almost indestructible and are designed to stand rough usage without depreciation.

The Electric Locomotive in Heavy Passenger and Freight Work.—A large number of present and proposed representative types of electric locomotives built by the General Electric Co. are illustrated and described in Bulletin No. 4537 now being issued. Sketches are given of electric locomotives weighing from 17 to 150 tons for all classes of service. Electric and mechanical data as well as the characteristic curves of each are given, also some interesting features of their construction.

Coal and Ash Handling Machinery.—The Jeffrey Mfg. Co., Columbus, O., is issuing a 56-page catalog illustrating and describing many recent installations of machinery for handling coal and ashes in power plants, which cover almost any conceivable arrangement for receiving, discharging and storing. This company manufactures conveyors and elevators of several different types, each one being specially adapted to certain conditions, all of which are illustrated in this catalog.

[illegible] Invention and Use.—The Norton Company, Worcester, [illegible] issuing a leaflet describing the manufacture of alundum and its value as an abrasive. Illustrations are included showing [illegible] in the manufacture of this material.

[illegible] Water Gauge.—The Ashcroft Mfg. Co., 85 Liberty street, [illegible] York, is issuing a pamphlet descriptive of its design of prismatic [illegible] gauge. The construction of the gauge is clearly explained and the [illegible] of this type over the ordinary water glass are shown. The gauge is so constructed as to fit in the place of the usual water glass, the [illegible] fittings being retained.

Portable Storage Batteries.—The Westinghouse Machine Company is issuing a very attractive catalog on the subject of portable storage batteries, which are illustrated in a great variety of sizes. The illustration of each type is accompanied by a table showing all of the important features, dimensions and capacities, as well as the price. The batteries of this type are used for car lighting, electric locomotives, electric vehicles, automobiles, etc. No batteries of the stationary type are shown in this catalog.

Automatic Gear Cutting Machine.—Gould & Eberhardt, Newark, N. J., are issuing a 60-page catalog illustrating and describing their different types of patented gear cutting machinery, which are the product of 60 years' experience as specialists in this line. The catalog shows machines for cutting spur gears, as well as for cutting bevel, skew and face gears. A section is given up to the description of attachments for these machines and a number of machines for special work are also illustrated.

Storage Batteries.—The Gould Storage Battery Co., 341 Fifth avenue, New York, is issuing a pamphlet which includes a thorough description of its special method of manufacturing plates for storage batteries, showing views of separate plates and complete installations. Bulletins Nos. 8 and 9 are also being sent out by the same company, the former describing the storage battery plant of the Dayton & Western Interurban Railway and the latter the plant of the Rutland Railway, Light and Power Company, which shows the application of storage batteries to alternating current systems.

Steels.—Samuel Bros., 132 Front street, New York, American agents for Cammell Laird & Co., of Sheffield, England, is issuing catalog B, covering the products of that company. This includes steels of practically all kinds for high speed tools, files, chisels, saws, springs, sheet steel, forgings, gears, axles, and in fact any appliances usually made of this material. The catalog is illustrated with views of the manufacture and colored plates of labels for different grades and also includes a colored chart giving the temperature corresponding to different shades as well as some very good advice in connection with the handling and heat treatment of tool steel.

Shapers.—Gould & Eberhardt, Newark, N. J., are issuing a very attractive catalog on the subject of high duty shapers and attachments. A large variety of these machines are very completely illustrated and the construction is described in detail. In the section on attachments for shapers are shown special designs of vises and mandrels, index centers, circular tables, automatic feeds, electric motor drive attachments and many special devices for doing work not ordinarily considered within the field of the shaper.

Electrical Apparatus.—The General Electric Company is issuing two new bulletins, one of which deals with direct current motor starting rheostats, shown in two types, both of which are suitable for use with shunt, compound or series wound motors. These rheostats are for one minute duty with a new [illegible] release and one of the types also has an overload coil. They are made in many different capacities. The other bulletin is on the subject of catenary line material. It contains 22 pages given up to a very complete description of the devices manufactured by this company for this class of equipment. It is profusely illustrated with views of catenary construction in detail, as well as general.

[illegible] Bearings for Railway Cars.—The Standard Roller Bearing Company, 50th Lancaster avenue, Philadelphia, is issuing a pamphlet giving [illegible] street car on the street railways of [illegible] fitted with [illegible] roller bearing, which consists of a [illegible] within a specially constructed [illegible] with a similar car fitted [illegible] per cent in the [illegible] which in this case [illegible] per year. The test is fully described [illegible] different cars are included.

[illegible] pamphlet just issued by the Cutler-Hammer [illegible] It contains a number of full page [illegible] stampings, [illegible] data on current [illegible] capacity of magnets, etc. A new [illegible] is made to the Cutler-Hammer [illegible] reaction, or "kick," [illegible] a magnet coil is [illegible] protecting the magnet [illegible] inside of the

Friction Clutches.—Catalog C from the Carlyle Johnson Machine Company, 256 Asylum street, Hartford, Conn., presents an illustrated description of the Johnson friction clutch and its various applications.

Sand Blast Apparatus.—Under the title of "Railroad Sandcraft," Mr. C. Drucklieb, 132 Reade street, New York City, has issued an interesting and valuable little pamphlet which discusses the uses and advantages of the sand blast in railroad shops and for cleaning bridges and steel work. A description of the Injector sand blast, which is manufactured by the above concern also appears, as well as directions as to its use. Where compressed air and dry sand are not available it is necessary to provide a supplementary outfit, which is briefly described.

The Electrification of the West Shore Railroad.—The General Electric Company is issuing a handsomely bound pamphlet of 24 pages in which the electrified section of the West Shore Railroad, between Utica and Syracuse, N. Y., is very completely illustrated and described. This is a direct current, 600 volt, third rail system, obtaining current by a 60,000 volt three phase transmission line from the hydro-electric power house of the Hudson River Power Company. Views of the electric trains, transmission lines, substations, plans of buildings, wiring diagrams and details of the track construction are shown and each feature is clearly described. Not the least interesting feature is a comparison of train sheets showing the service before and after electrification.

NOTES

Baldwin Locomotive Works.—This company received a diploma of a gold medal for a most admirable, efficient and artistic installation of exhibit at the Jamestown Exposition.

Kennicott Water Softener Company.—This company is furnishing a great many steel water storage tanks to different railroads. They are said to be much more economical than the wooden ones, as they last twice as long and cost less than one-half as much to maintain.

Pressed Steel Car Company.—The Pressed Steel Car Company and the Western Steel Car and Foundry Co., have opened offices in the National Bank of Commerce Building, 5th and Olive streets, St. Louis, Mo., with Mr. W. P. Coleman, assisted by Mr. C. D. Terrell, in charge.

American Locomotive Company.—The directors of this company, in a meeting held on November 6, re-elected the retiring officers to serve for the ensuing year. Mr. S. P. Callaway was elected to succeed Mr. Leigh Best as secretary. Mr. Best continues to hold the office of vice-president.

Iron and Steel Brokers.—H. B. DeHart and W. H. Stafford have established an office at 29 Broadway, New York, for the transaction of a general commission and brokerage business in iron and steel products, including structural work, shapes, bars, light rails, malleable and steel castings, cast iron, etc. Both members of the firm are engineers and have had long experience in this field.

American Blower Company.—In the exhibit of this company at the conventions of the American Street and Interurban Railway Associations at Atlantic City, was included the suspended ball feature which attracted so much attention at the mechanical conventions in June. The explanation of the phenomenon of the ball remaining suspended in the air without apparent support can be secured by addressing the company at Detroit, Mich.

Meeting of the A. S. M. E.—The 54th annual meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies Building, New York, December 3 to 6. The subjects to be taken up at this time include foundry practice; specific heat of superheated steam; low grade fuels in gas producers and other live topics such as industrial education, power transmission by friction, cylinder port velocities, etc., will be discussed.

Westinghouse Receivership.—The receivers of the Westinghouse Machine Company announce that there should be no occasion for apprehension because of the company's application for receivership. This action was taken as being the most sensible measure for conserving the interests of the customers, creditors, and stockholders of a solvent institution, which is doing a large and profitable business. There will be no departure from the general policy as heretofore followed in the conduct of the business and no phase in the operations of the company, the personnel of which remains the same as heretofore.

Carse Brothers Co.—The resignation of Mr. Davis B. Carse from the chairmanship of the advisory committee of the United States Steel Corporation will permit him to again actively take up the business of the above company, which deals largely in machinery and supplies for railway work. The company has been recently reorganized and its headquarters have been removed from Chicago to 12 Broadway, New York. In reorganizing the company it has incorporated with it a department for electrical specialties, which will place it in a position to handle the electrical equipment of electrified steam railways.